BOOSTER NOTCH ABSORBER DESIGN.

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Notching Absorber Design, Overview.

The conceptual design of the Booster Notching Absorber is based on **Primary beam loss calculations at notching** and **Energy deposition simulations with MARS**. The New Booster Notching Absorber will be located in the Long 13 section of the Booster Ring.

Fig.1 Booster Ring, Long 13.

1. **Booster Notching Absorber Components.**

The vacuum liner (item 1) is surrounded with steel absorber (item 2) and concrete (item 3) blocks. Polyethylene masks (item 4) are mounted around the vacuum liner tube extension in the upstream and downstream ends of the absorber. The driving system (item 5) provides 1.00" movement of the vacuum liner inserted into the moving block (item 6) . Two bellows (item7) are connected to the vacuum liner and to the Booster beam pipe. The marble blocks, four inches thick (item 8 and 9), are installed on the aisle side and downstream end of the absorber. The steel –marble mask (item 10) is installed on the downstream end of the absorber. Three steel frames (item11) hold marble and concrete blocks in the place.

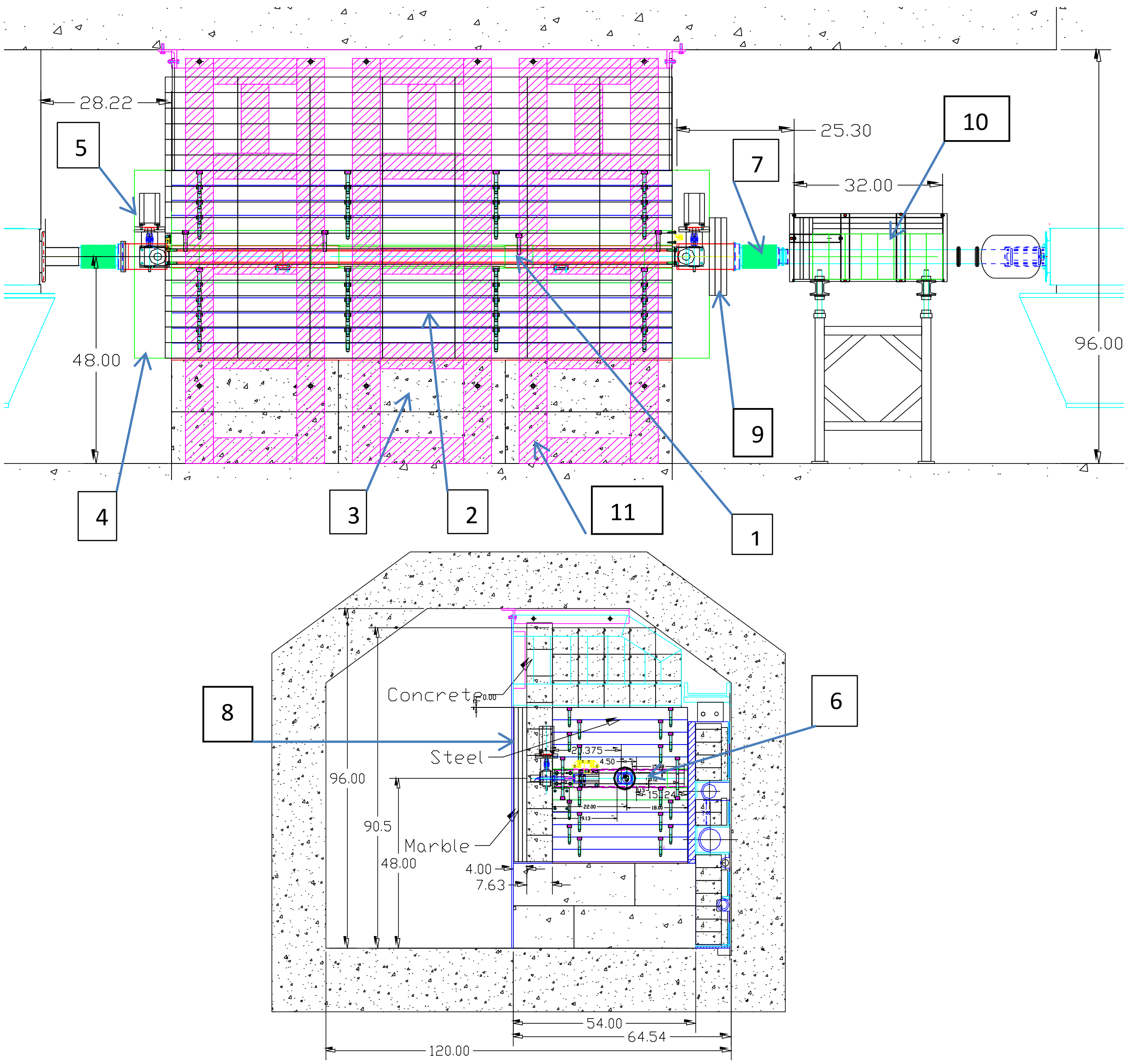

Fig.2 Booster Notch Absorber.

Vacuum Liner Design.

Vacuum liner is welded from 3.25”x4.5”x110.38” rectangular stainless steel tube with 2.75” hole diameter, two 6” quick disconnect flanges, 6’’ OD tube and two end round plates. Two thermocouple groves are milled on the wall side of the liner. The center of the liner strait hole and the center of the Booster beam pipe hole are fair in the neutral position. The liner edge is located 0.79” (20mm) from the center of the beam in the operation position. Two groves are milled on the aisle side of the liner for thermocouples locations. The kick side of the line is located on the aisle side of the absorber.

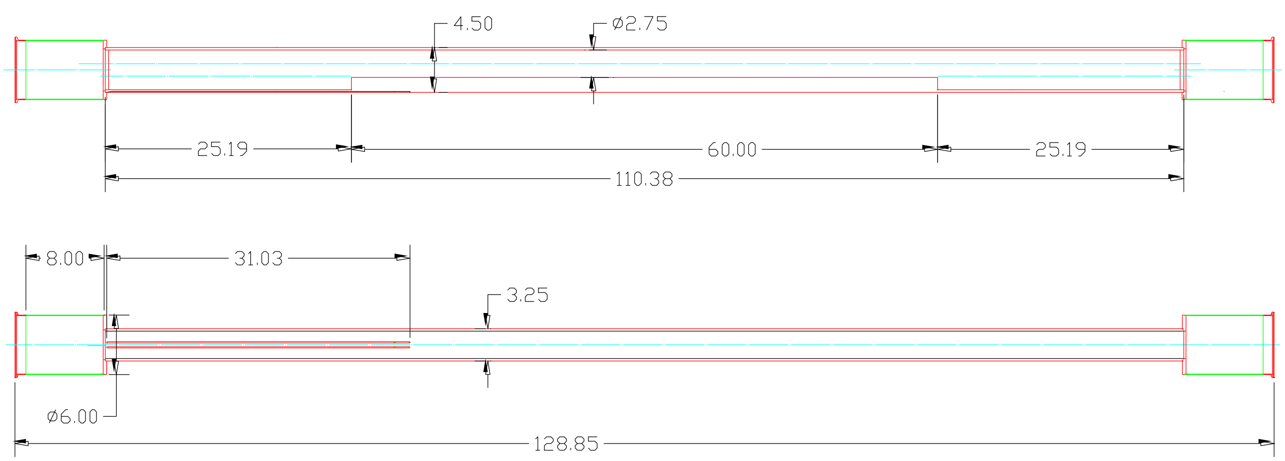

Fig.3 Vacuum Liner.

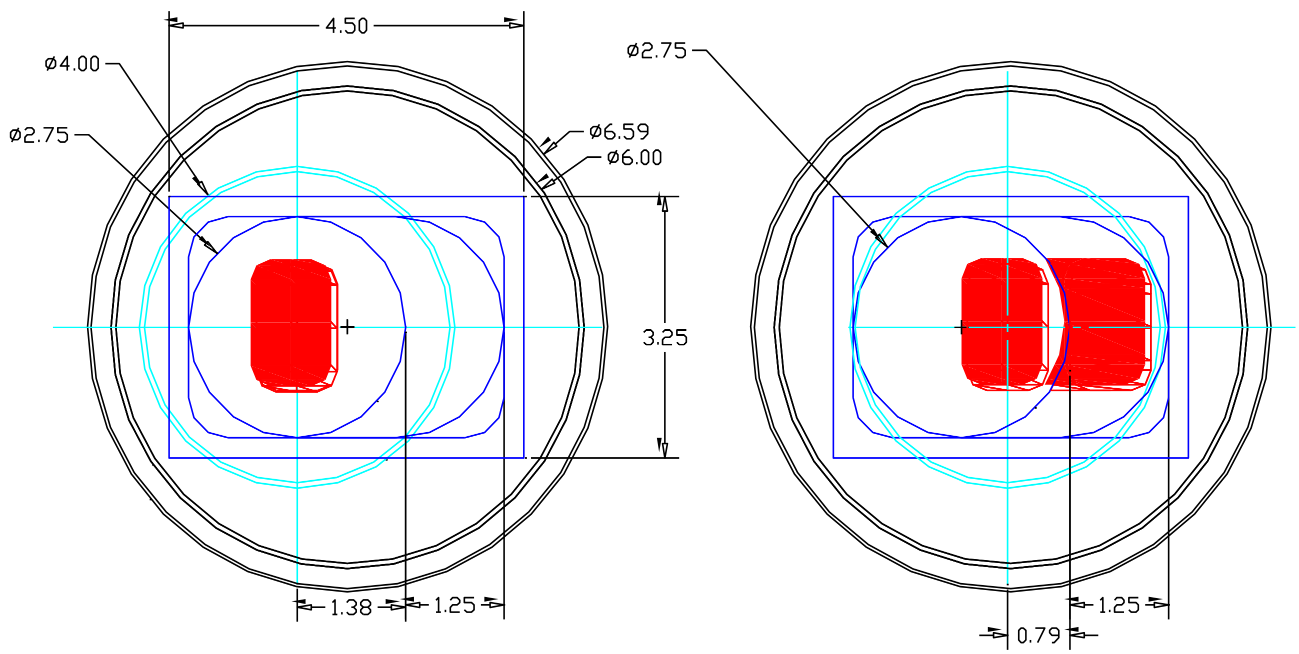

Fig.4 Vacuum Liner, neutral position.

Fig.5 Vacuum Liner, working position.

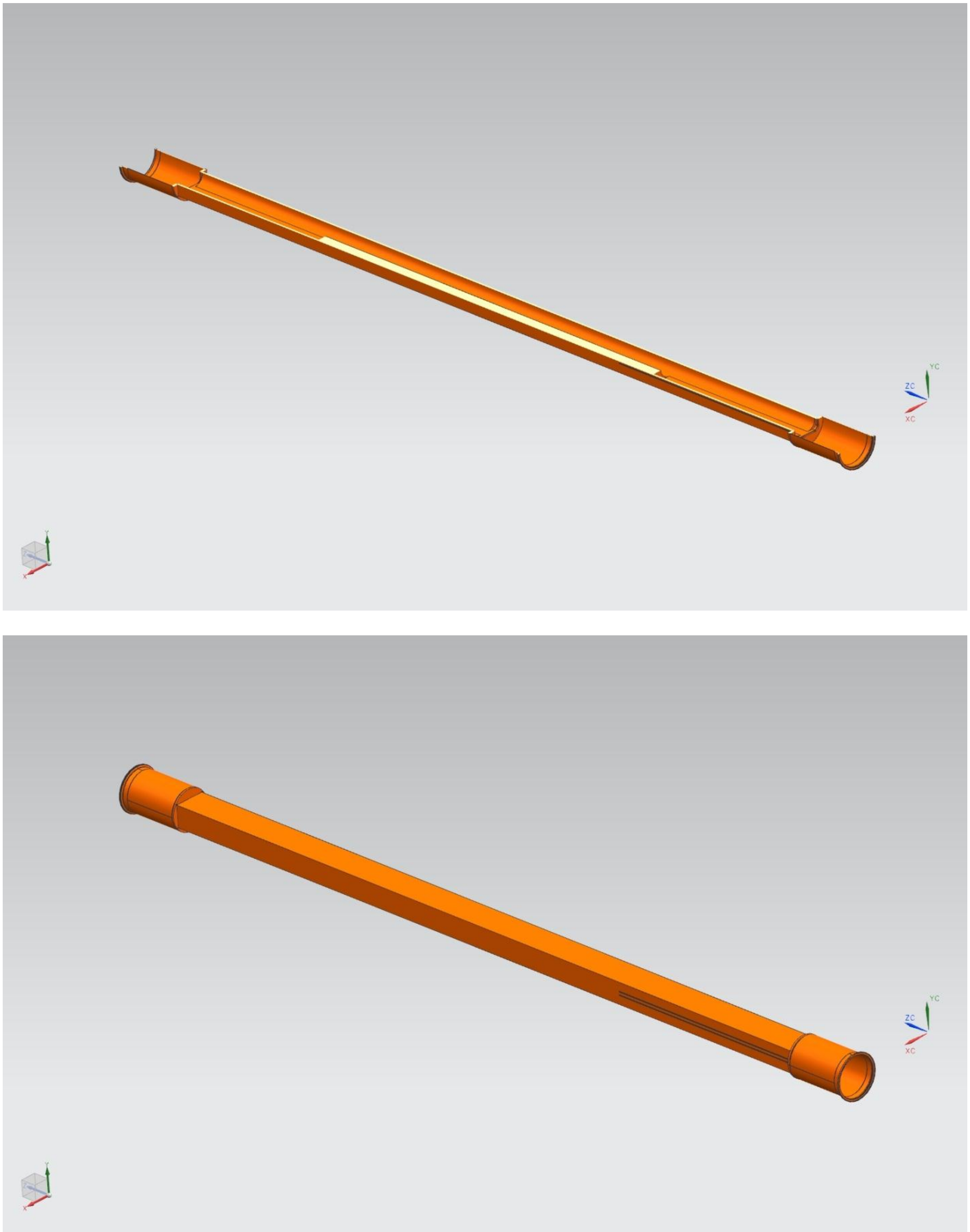

Fig.6 Vacuum liner 3d pictures.

Moving Block.

The moving block is assembled from three bottom plates two side blocks, vacuum liner between blocks and three top plates. The vacuum liner and side blocks must have proper contact for a heat transfer. Two pivot brackets are bolted to the both ends of the moving block for the screw jacks clevis connection.

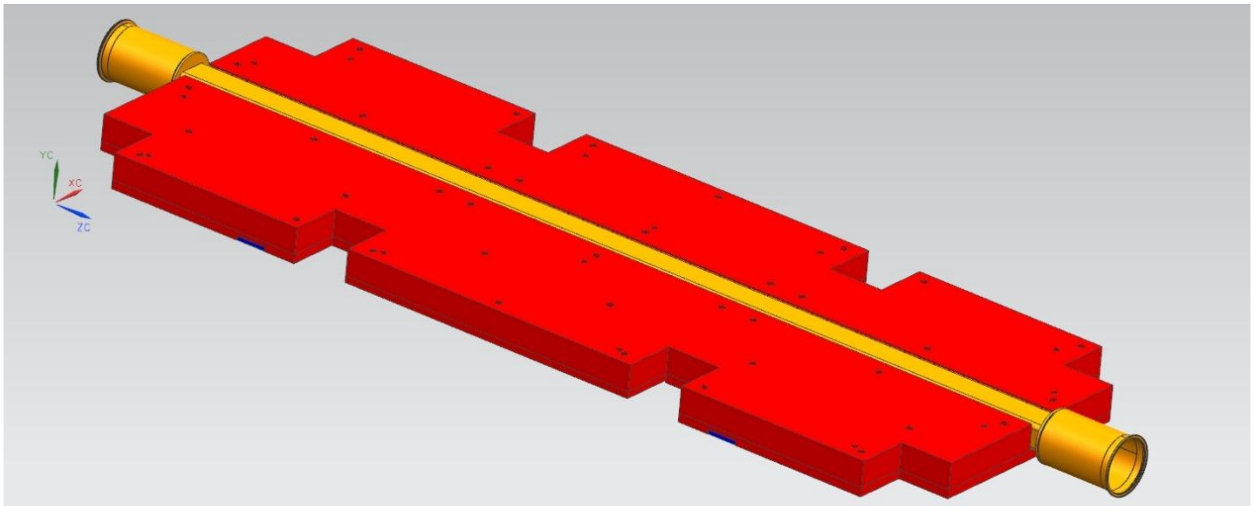

Fig.7 Vacuum Liner inserted into the shielding.

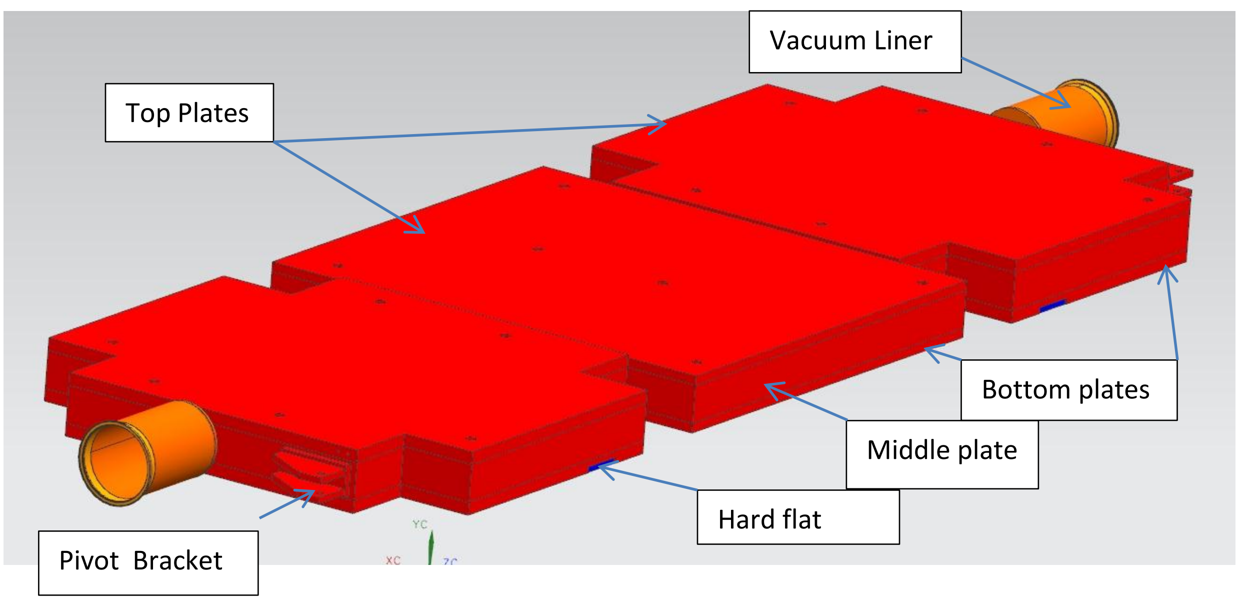

Fig.8 Moving block assembly.

Moving Block and support plates assembly

The bottom base plate of the moving block is bolted to the bottom shielding blocks assembly. The base plate has eight support stands to support the top portion of the steel shielding. Four flat rollers are placed on the hard bearing plates to support the moving block.

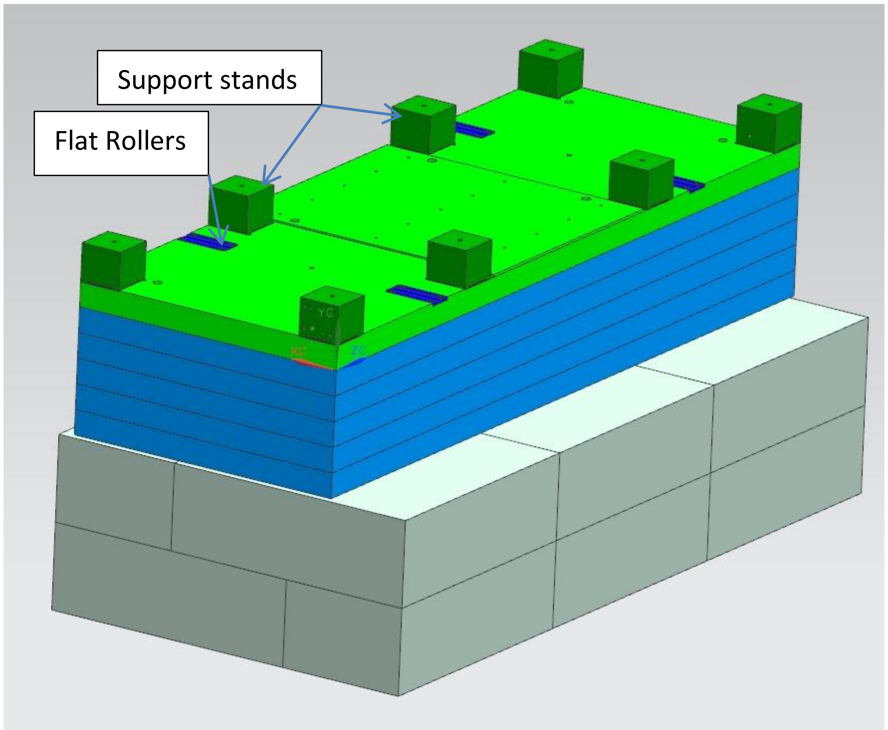

Fig.9 Base plates with flat rollers and top shielding support stands.

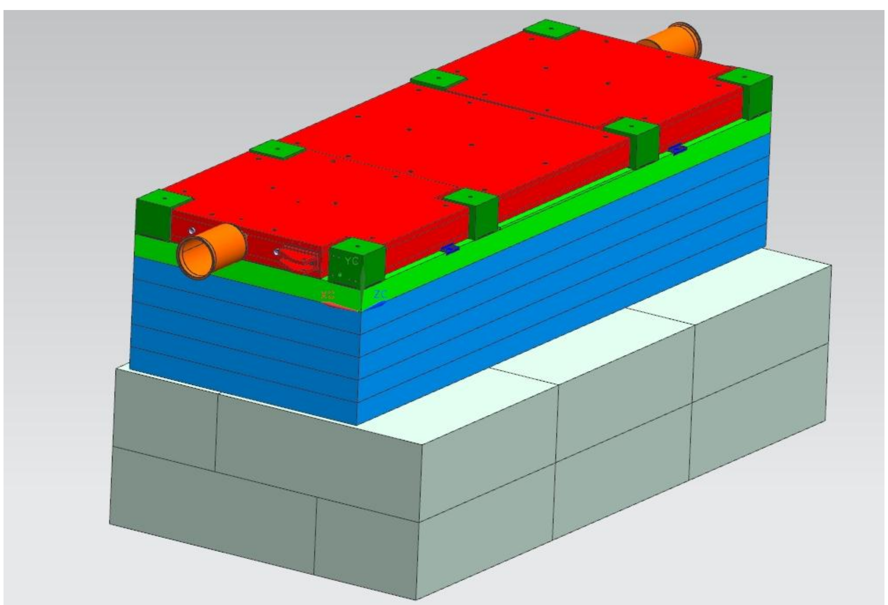

Fig.10 Moving Block placed on the base plate flat rollers

The top plate is bolted to the base plate stands and supports the top portion of the absorber shielding. Two screw jacks 2.5 ton capacity are mounted on the base plate stands and connected to the moving block pivot bracket.

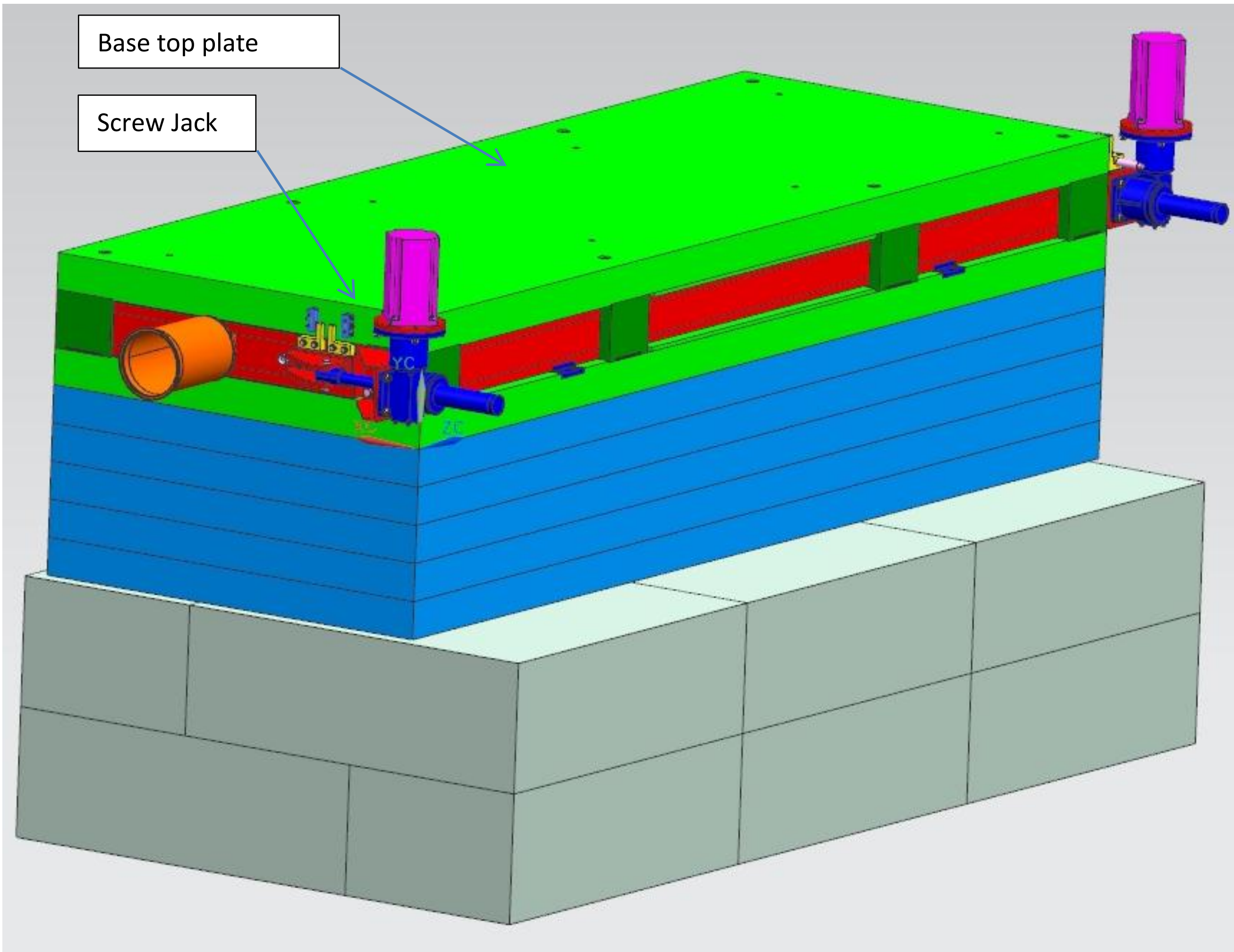

Fig.11 Moving block assembly.

Top steel shielding plates are bolted to the moving block base top plate and to each other.

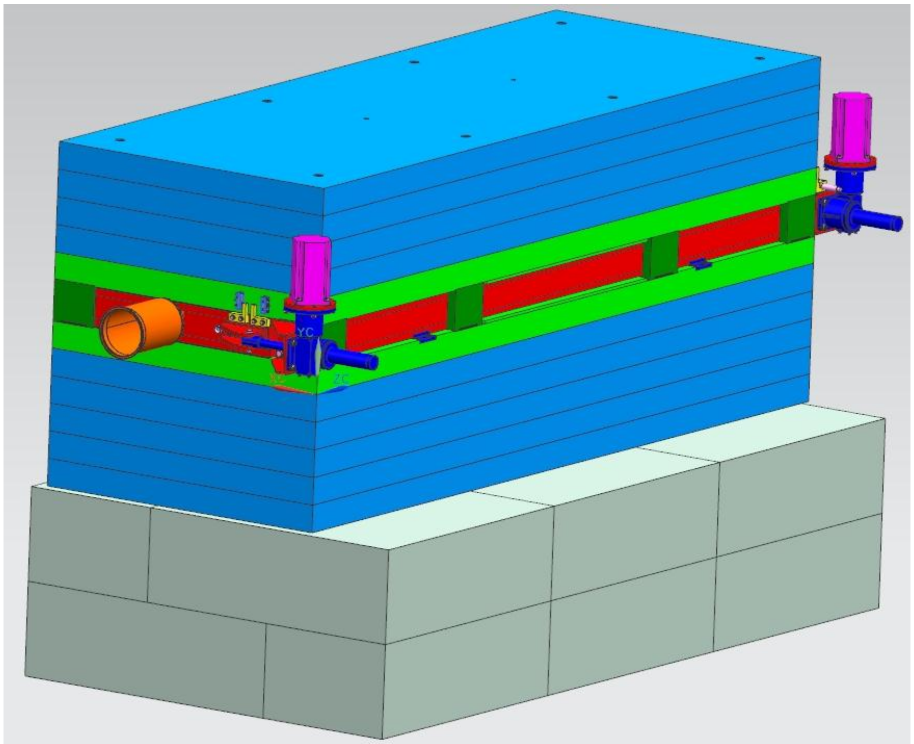

Fig.12 Top steel plates installation.

Two polyethylene masks are installed on the steel shielding on upstream and downstream end of the absorber.

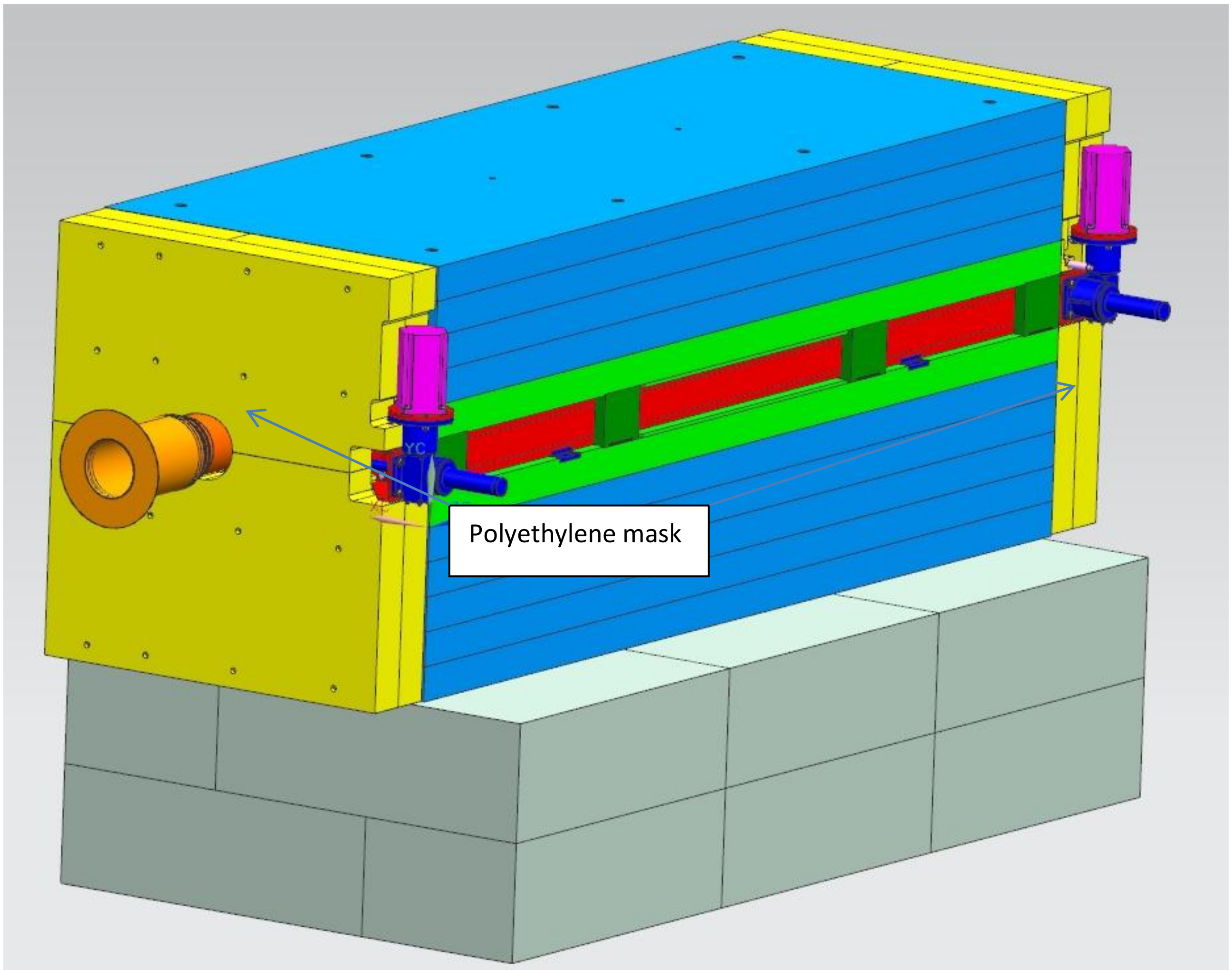

Fig.13 Polyethylene masks installation.

Concrete blocks are surrounded the steel shielding from the top and aisle side of the absorber. Four layers (4 inches) of a marble are installed on the aisle side of the absorber and secured with frame.

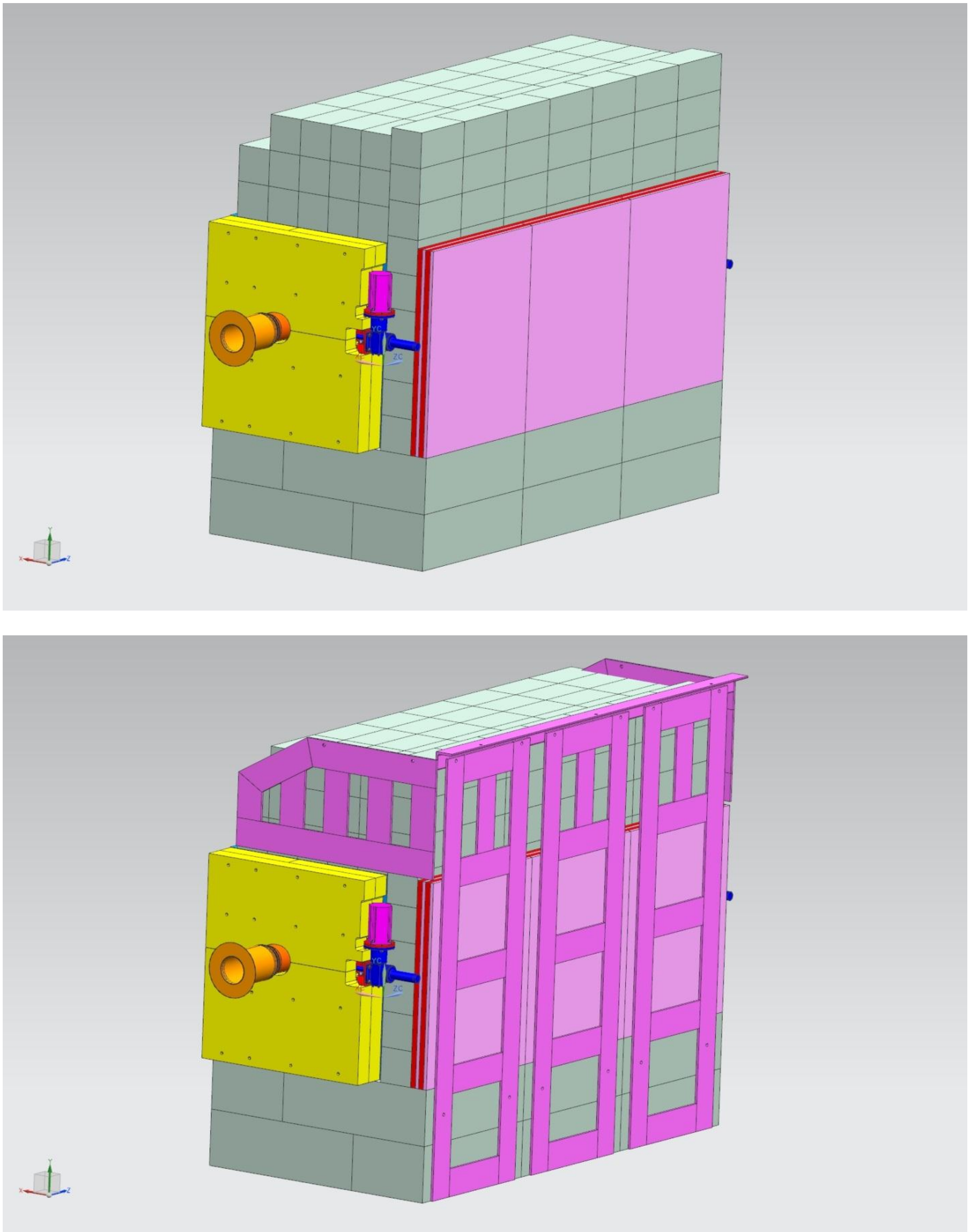

Fig.14 Concrete blocks and marble installation.

Control System.

The horizontal LVDT (item1) control the position of the moving block during operation and connected to the ACNET. Limit switches and (item 2), keep the moving block in limits (1.0” horizontally) and protect motors from the overdrive. Two thermocouples are inserted into the vacuum liner. One of them is connected to the ACNET.

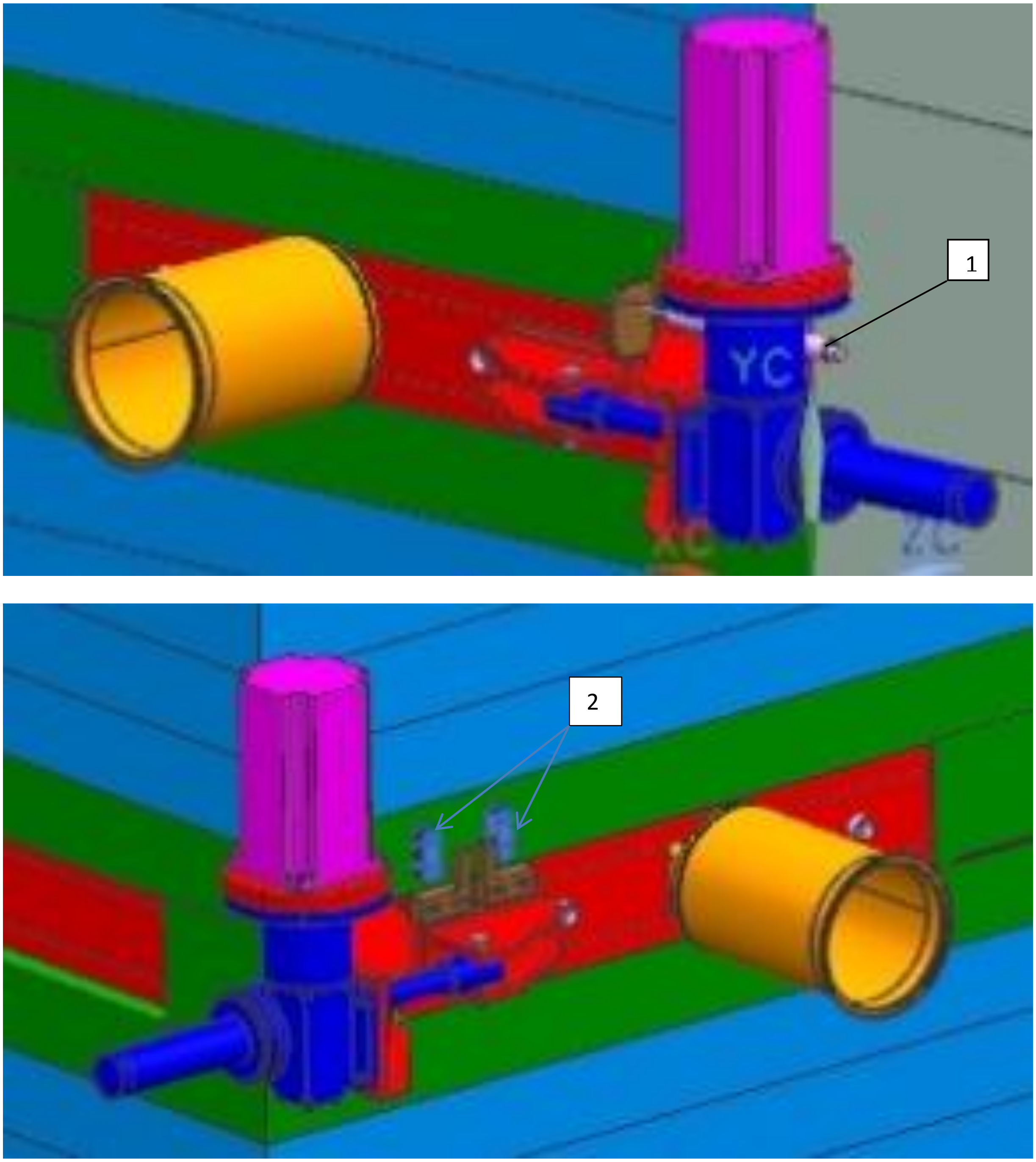

Fig.15 LVDT and Limit Switches location.

Motion System .

Two Action Jack 2.5-MSJ-series screw actuators, 24 : 1 ratio, are used to push-pull 6,200 pounds of the moving part of the absorber. Required push-pull force is: 6,200x 0.8= 4,960 lb. Where: 0.8 – coefficient of static friction between rollers and absorber steel block in case of sliding.

2.5-MSJ SPECIFICATIONS

GEAR RATIO	CAPACITY (lbs.)	LIFTING SCREW (in.)			TURNS OF WORM FOR 1" TRAVEL	MAX INPUT TORQUE (in.-lb.)	MAX ALLOWABLE INPUT (HP)	MAX WORM SPEED AT RATED LOAD (RPM)	
		DIAMETER	LEAD	ROOT DIA.				NON-KEYED	KEYED
24:1	5000	1	0.25	0.698	96	53	0.5	594	516

MAX LOAD AT 1750 RPM (lbs.)		TORQUE TO RAISE 1 LB. (in.-lbs.)		TARE DRAG TORQUE (in.-lbs.)	STARTING TORQUE (in.-lb.)	WEIGHT (Approx. in lbs.)			PDF PAGE
NON-KEYED	KEYED	NON-KEYED	KEYED			"0" TRAVEL	PER INCH OF TRAVEL	GREASE	
1699	1476	0.0106	0.0122	5	0.0212	17	0.45	0.5	323

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1. Determine Unit Running Torque: (T1) (lb-in)

T_1=0.0122x4960/2 = 30.25

0.0122 – Torque to raise 1 lb (from chart)

2. Find Unit Power:

HP = (T_1 x RPM) / 63025 = 30.25 x 300 / 63025 = 0.15

3. Determine Unit Starting Torque: (Ts)

Ts=2T_1 = 30.25 x2= 60.5

4. Motor selected:

. Anaheim Automation Stepper Motor NEMA 42 K Series, 42K322S-CB8, Motor speed- 5 RPS, Torque – 4000 oz-in.

5. Motor running torque: (lb-in)

1200/ 16 = 75 >30.25

6. Motor Power: (HP)

75 x 300 / 63025 = 0.357 >0.15

7. Motor starting torque: (lb-in)

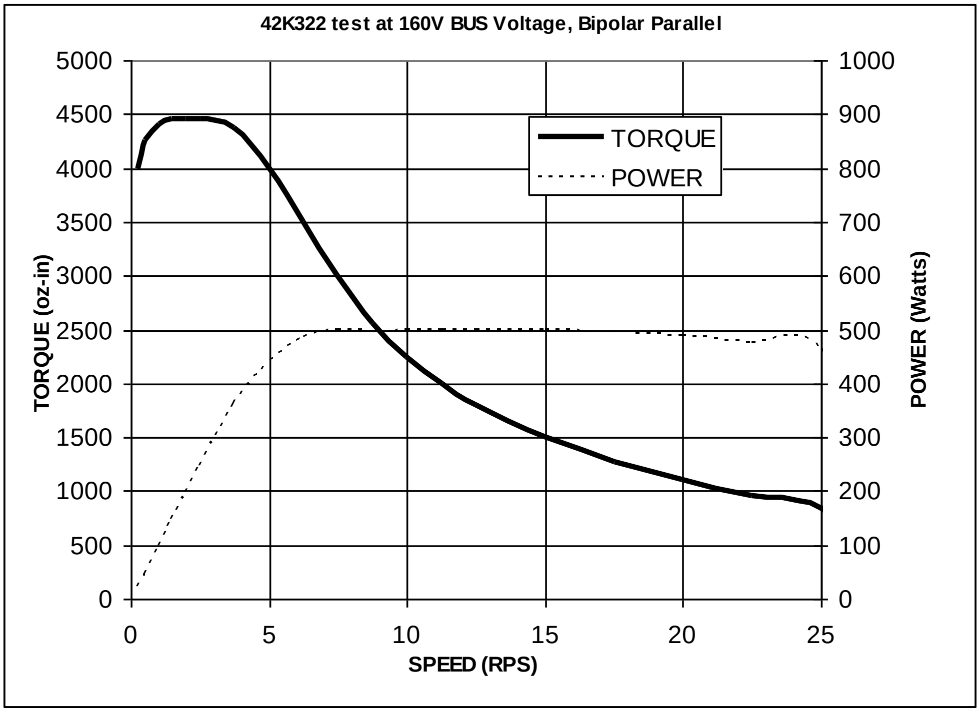
2720 / 16 = 170 > 60.5

8. Time to move 1”

Travel time –0.32 min=20sec., Travel speed 3.125 in / min

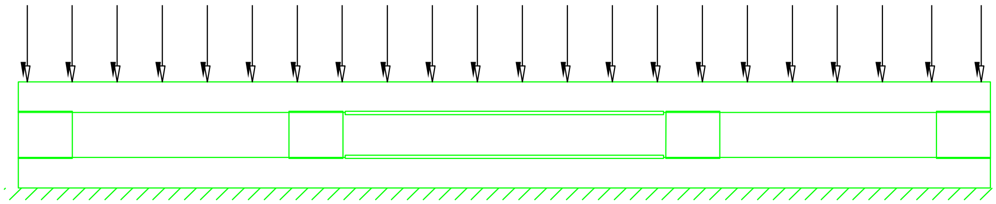
Calculated Torque Chart for Stepper Motor 42K312.

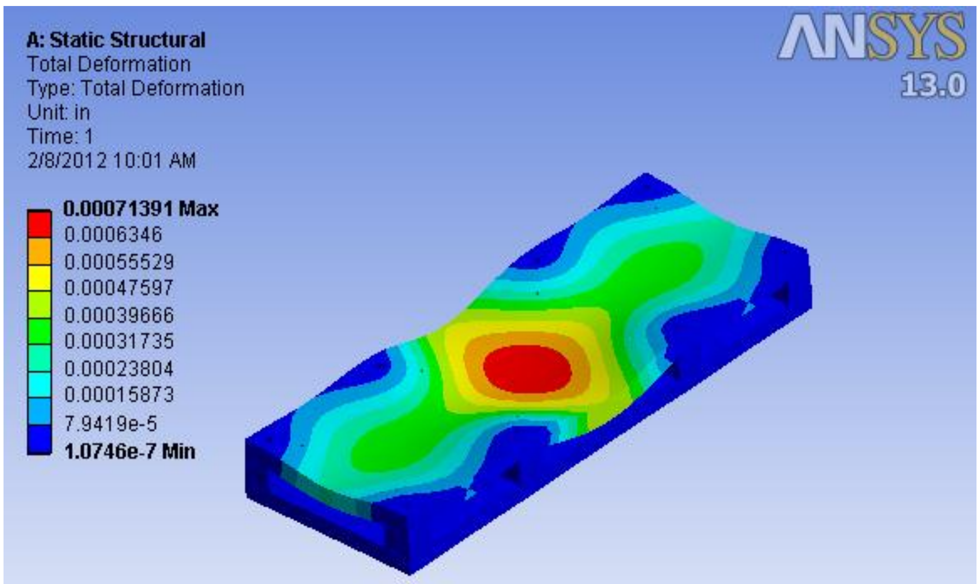
SPEED			
PPS	RPS	TORQUE	POWER
400	0.25	4000	22.18
800	0.5	4250	47.1325
1600	1	4400	97.592
2400	1.5	4450	148.0515
3200	2	4450	197.402
4000	2.5	4450	246.7525
6000	3.75	4375	363.890625
8000	5	4000	443.6
10000	6.25	3500	485.1875
12000	7.5	3000	499.05
14000	8.75	2550	494.89125
16000	10	2250	499.05
18000	11.25	2000	499.05
20000	12.5	1800	499.05
24000	15	1500	499.05


42K322 test at 160V BUS Voltage, Bipolar Parallel
TORQUE
POWER
TORQUE (oz-in)
POWER (Watts)
SPEED (RPS)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25

Moving Block Base FEA Calculations.

Top steel shielding plates and concrete blocks (Total weight 23350lb) are supported by the base plate. The calculation pressure is 5.4 Psi.





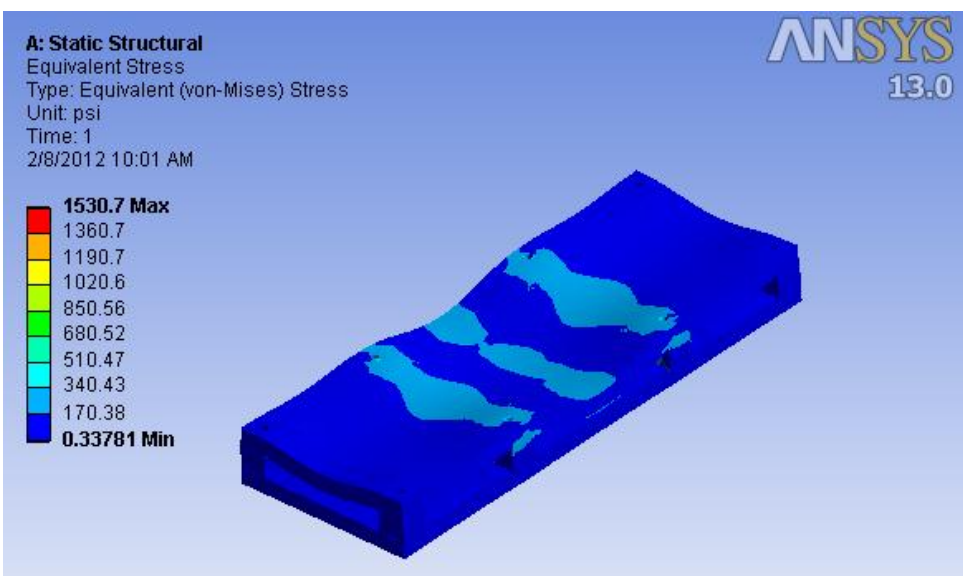
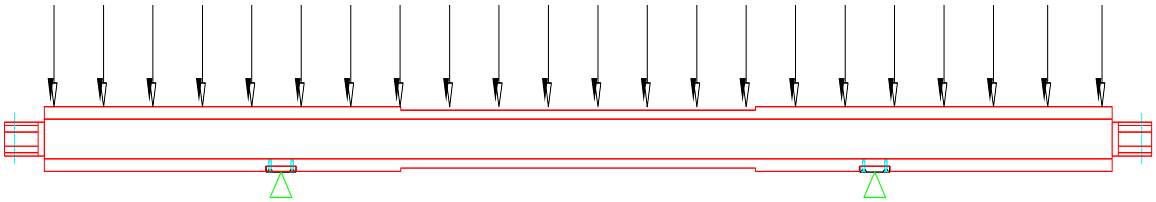
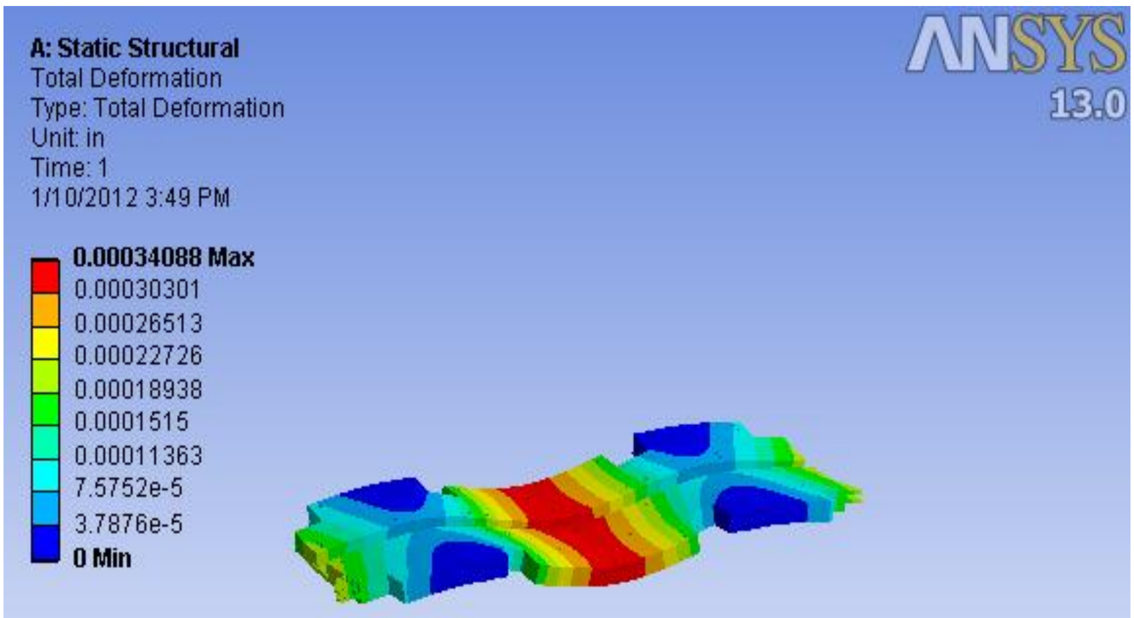


Fig. 16 Moving block base stress and deformation.

Moving block FEA Calculations.

The weight of the moving block is supported by four roller bearings. The deformation and stress from own weights are shown below. The calculation pressure is 1 Psi.





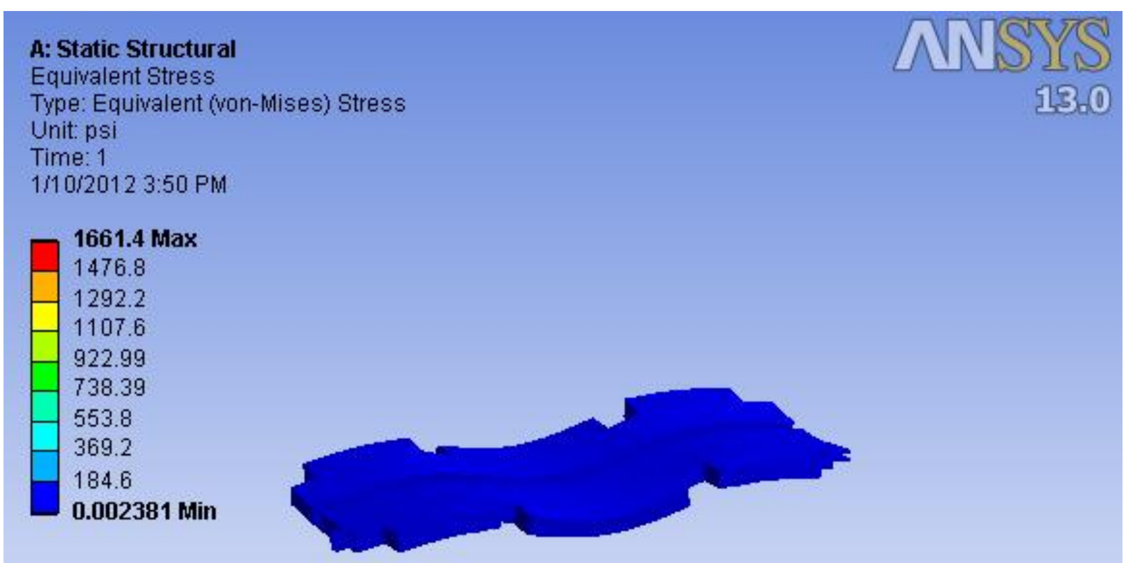
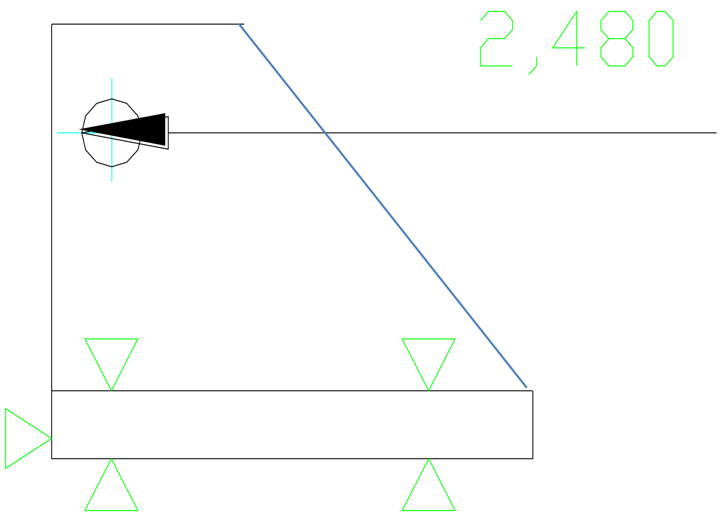
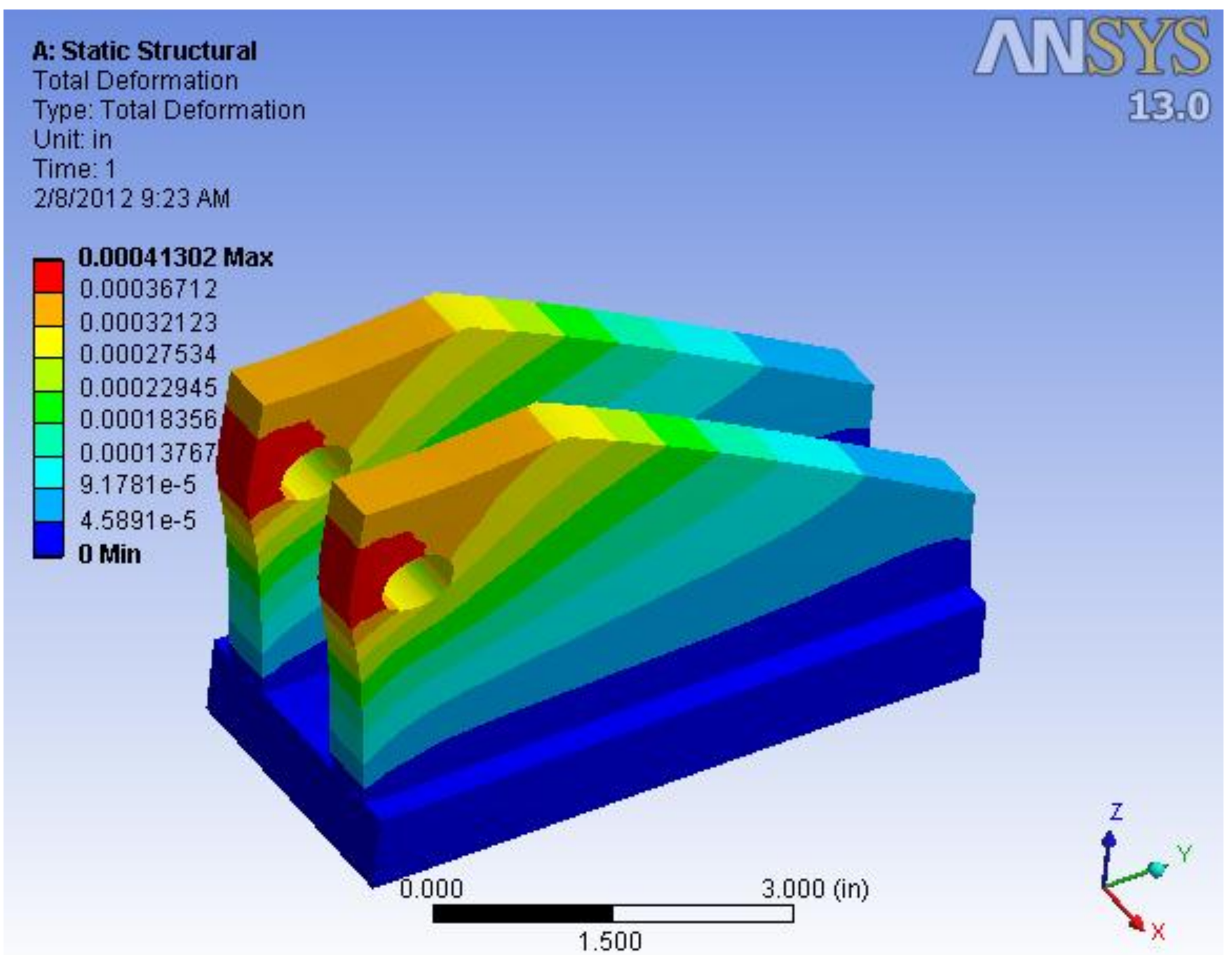


Fig.17 Moving block parts stress and deformation.

Moving block pivot bracket FEA calculations

The push-pull force applied to the pivot bracket is 2480lb.





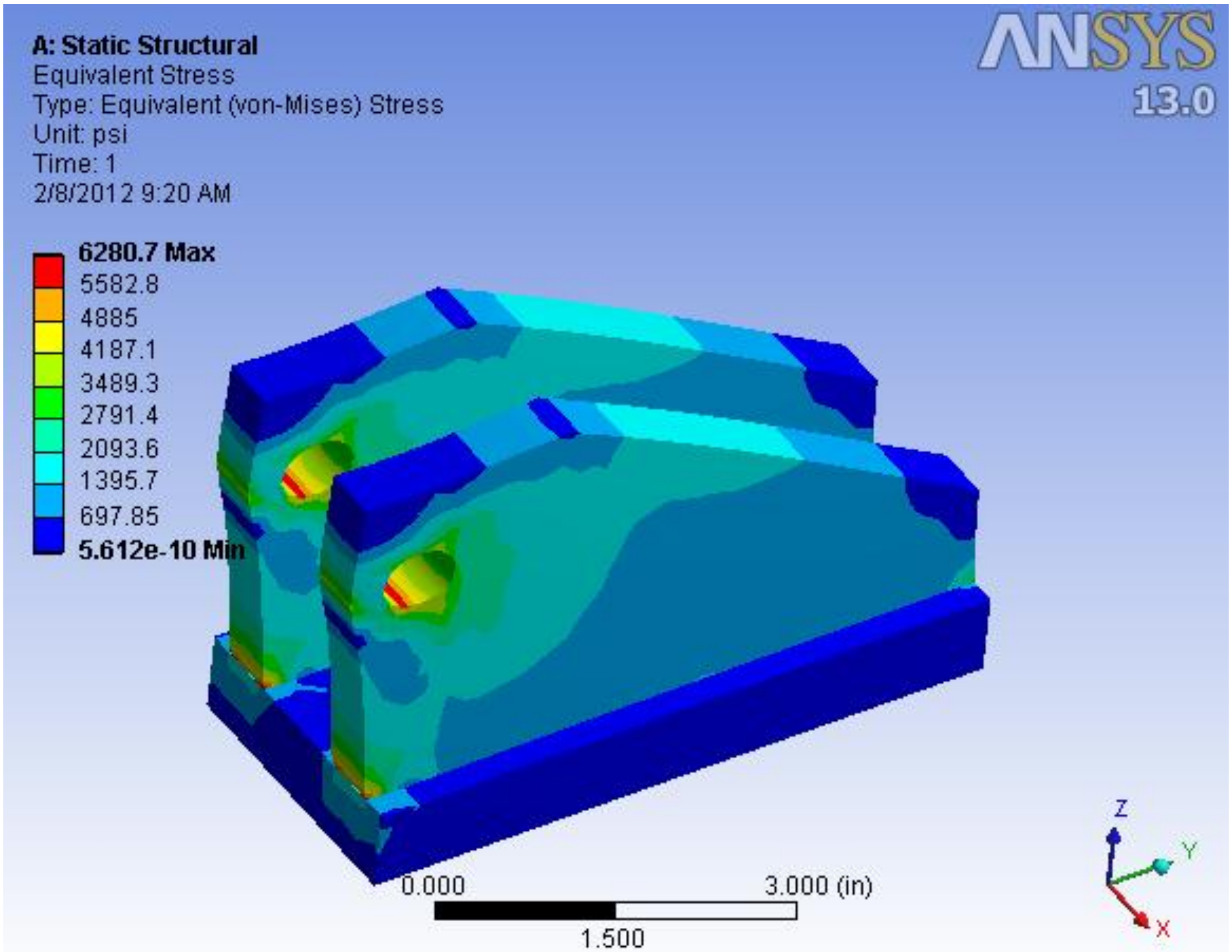


Fig.18 Pivot Bracket stress and deformation.

MARS calculations

MARS calculations the star density behind the tunnel concrete wall and operation and residual dose in the tunnel.

Required limit of the star density is 4000.

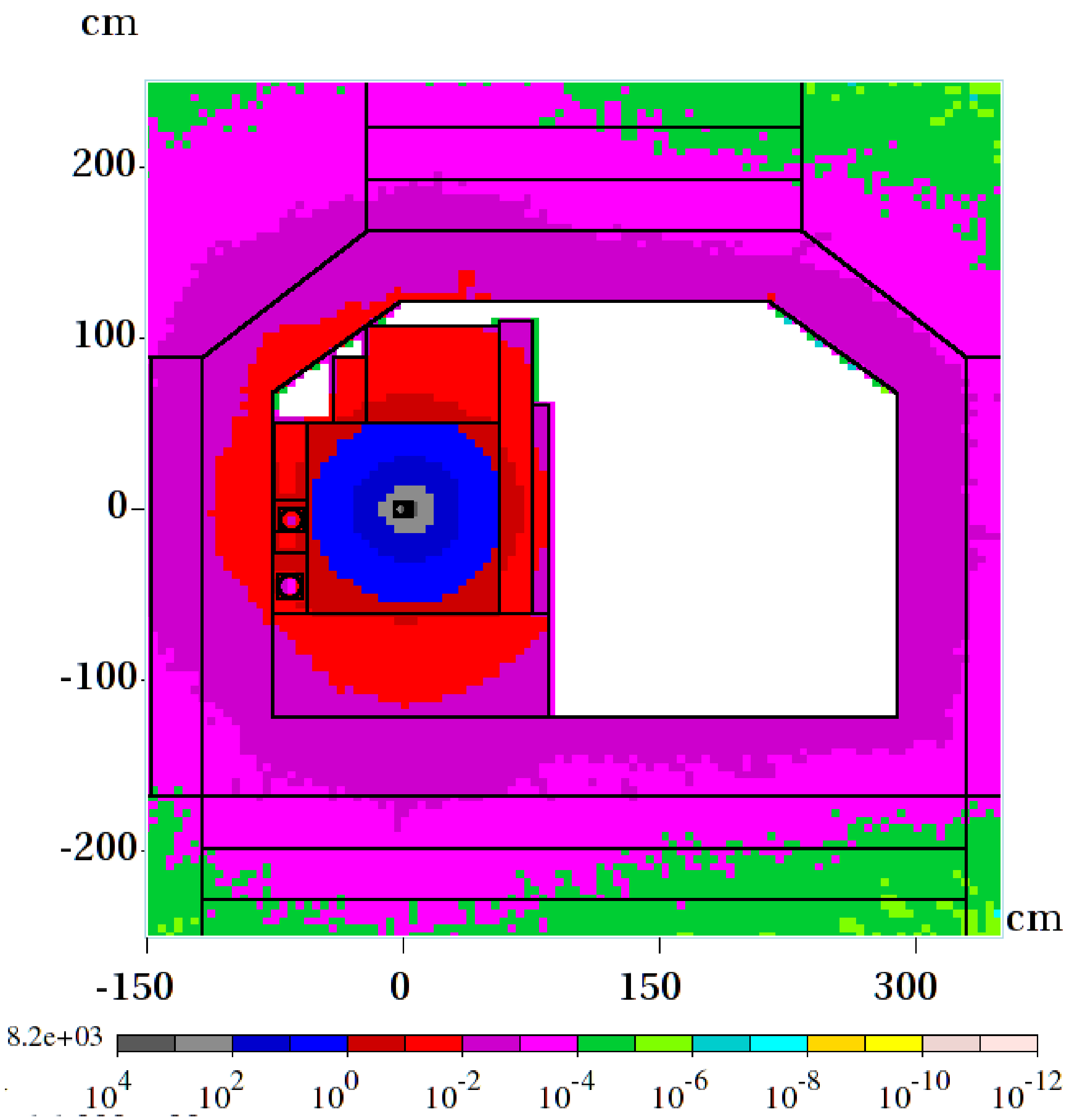


Fig.19 Energy deposition, MARS Calculations (residual dose).

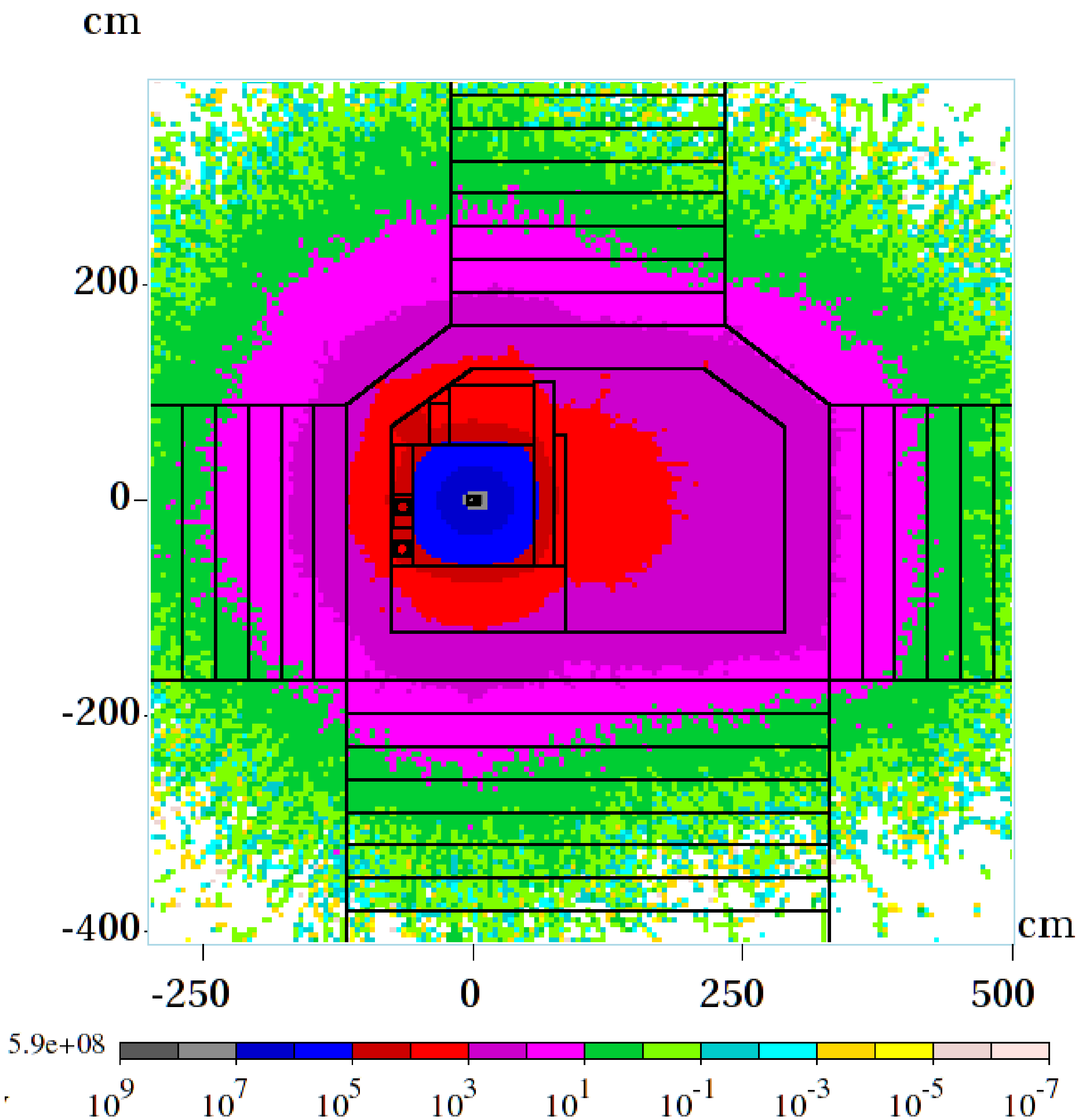


Fig.20 Energy deposition, MARS Calculations (operation dose).

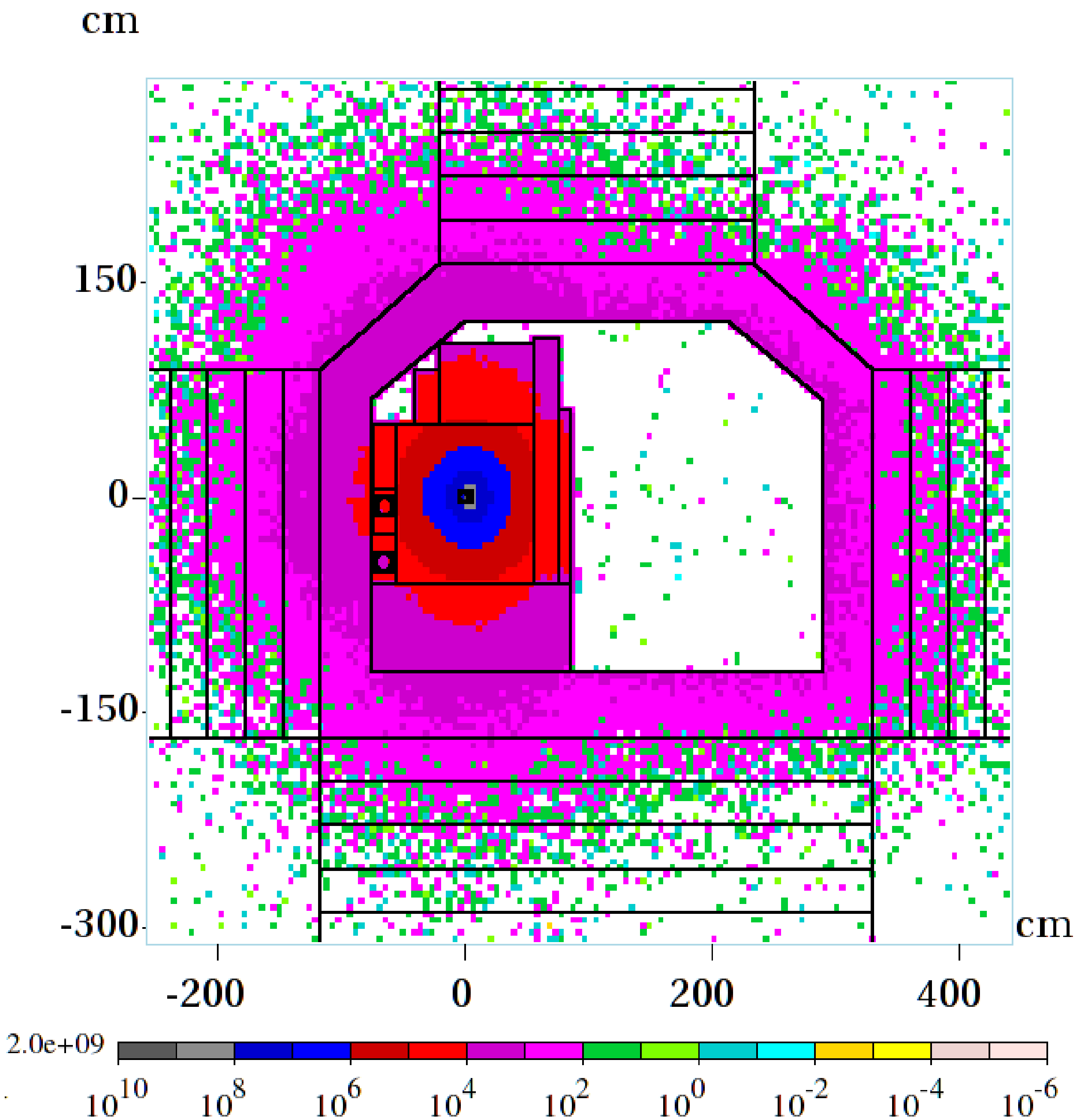


Fig.21 Energy deposition, MARS Calculations, Star Density .

The Star Density will be about 3000.

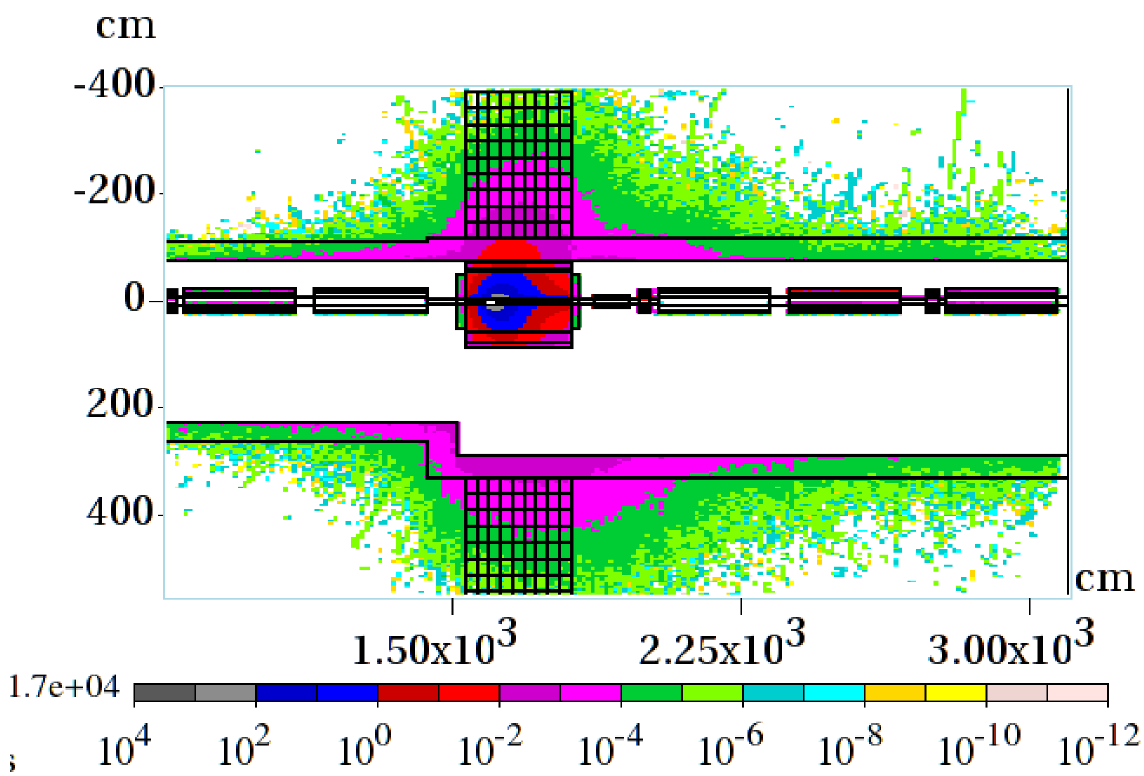


Fig.22 Energy deposition, MARS Calculations, plan view (residual dose).

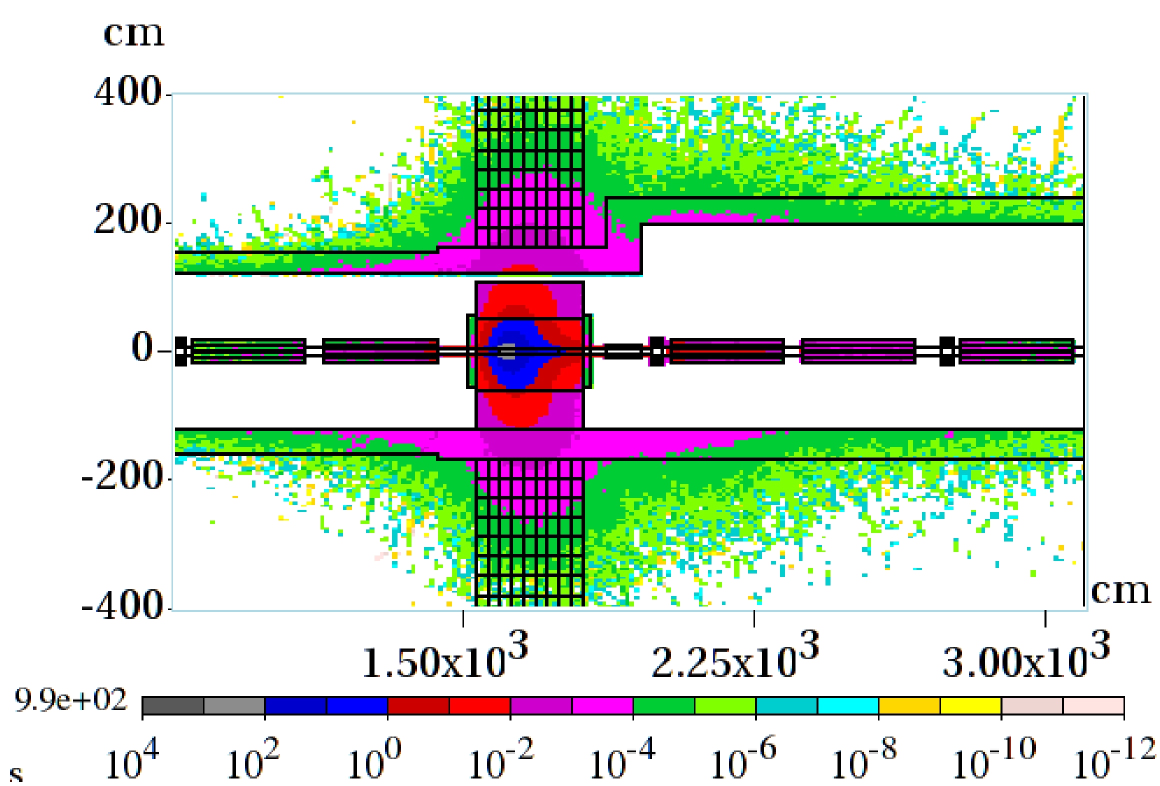


Fig.23 Energy deposition, MARS Calculations, vertical view (residual dose).

Thermal Analysis

The Absorber Liner jaw will be heated by energy deposition of three bunches from 84 of the beam.

Proton per pulls: $5x10^{12}$, 15Hz , 700 MEV.

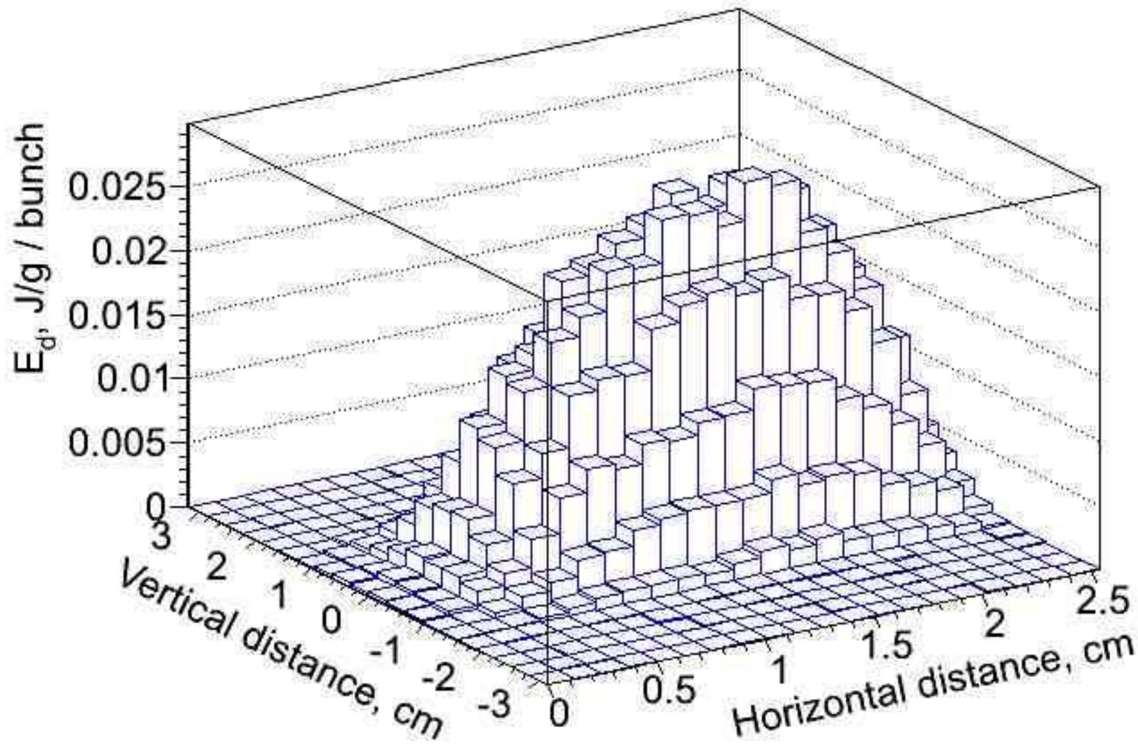


Fig.24 Energy deposition.

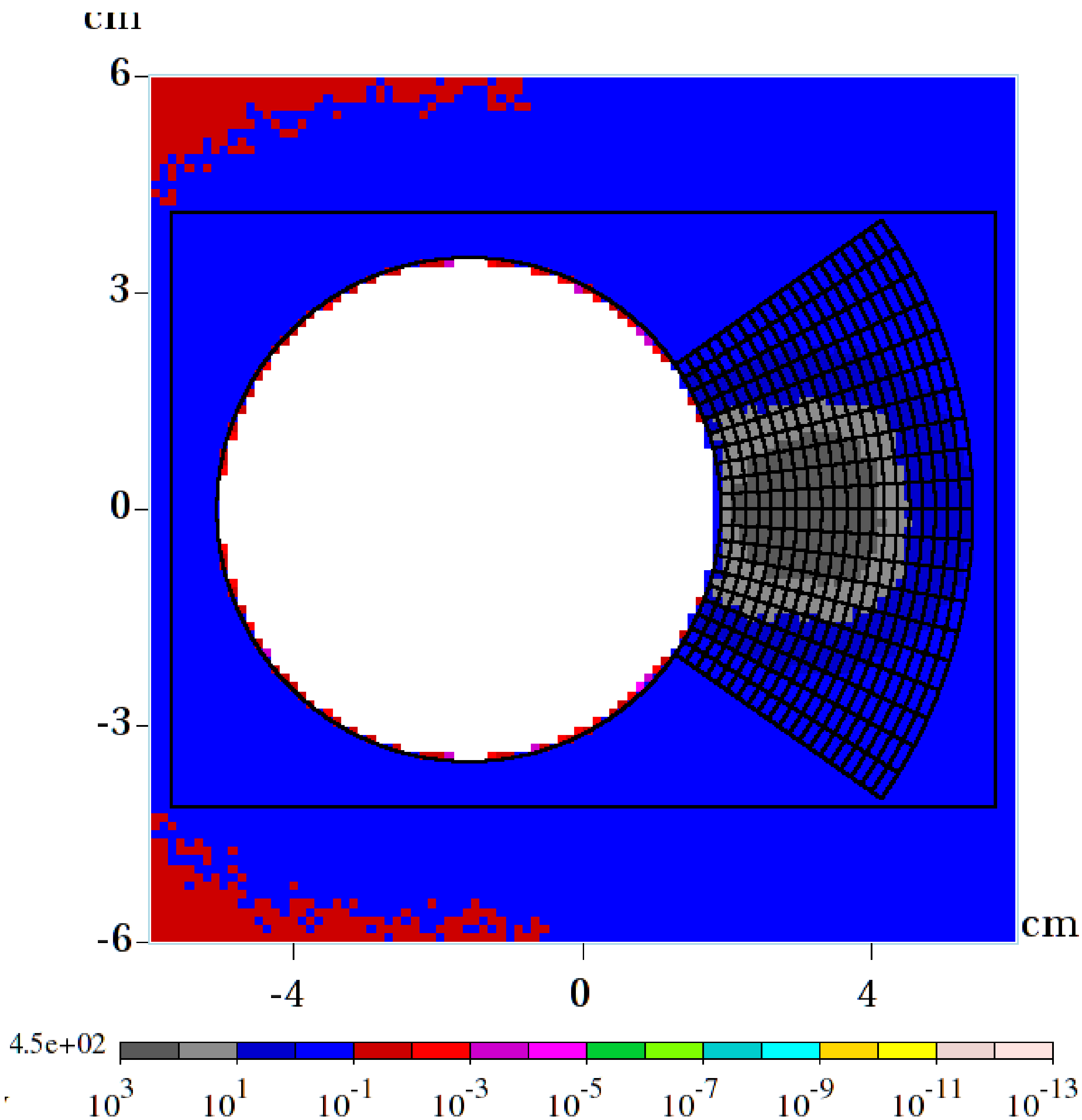


Fig.25 Energy deposition (mwatt per gram).

The conductive heat transfer is used in this calculation only.

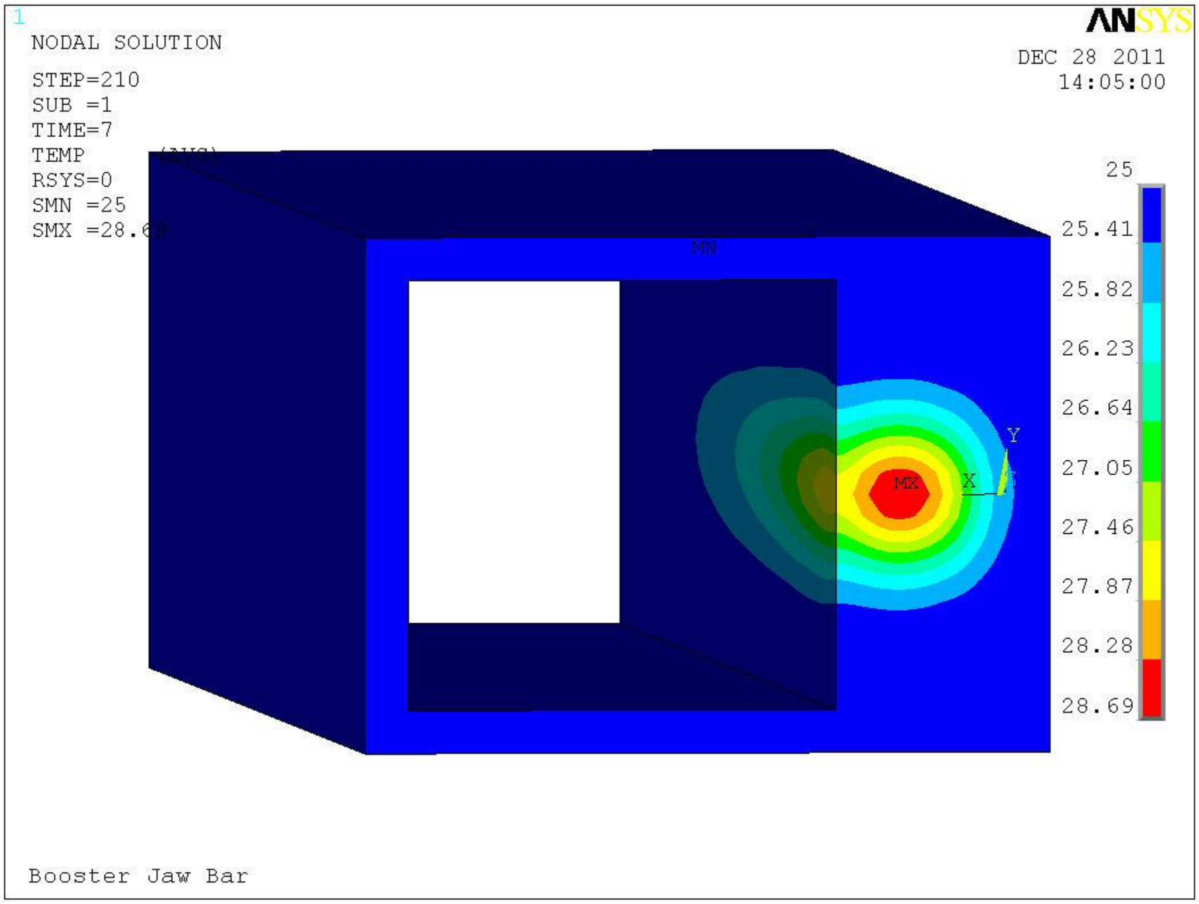


Fig.26 Model 1: Piece of tube with jaw inside two feet long is heated by beam.

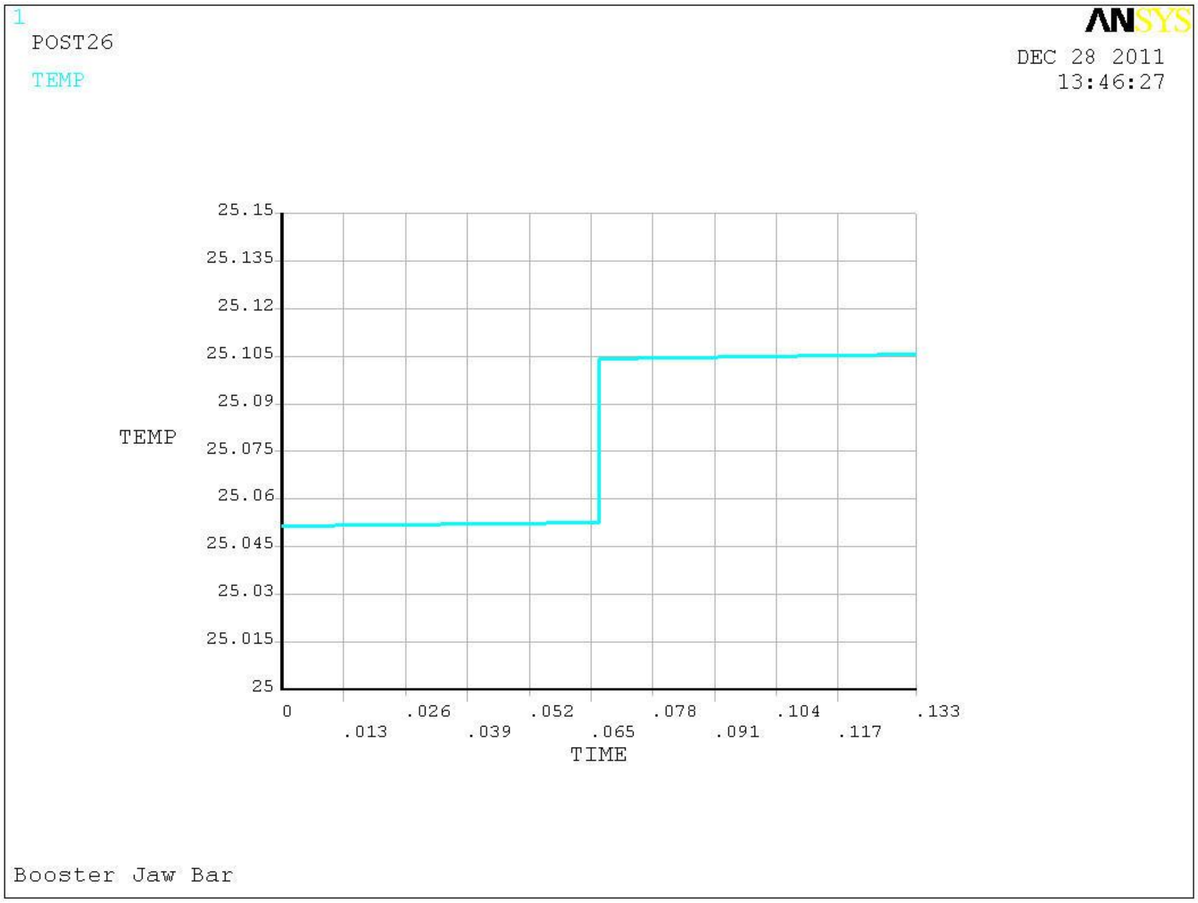


Fig.27 Instant temperature- rise per pull is 0.6^{o}C.

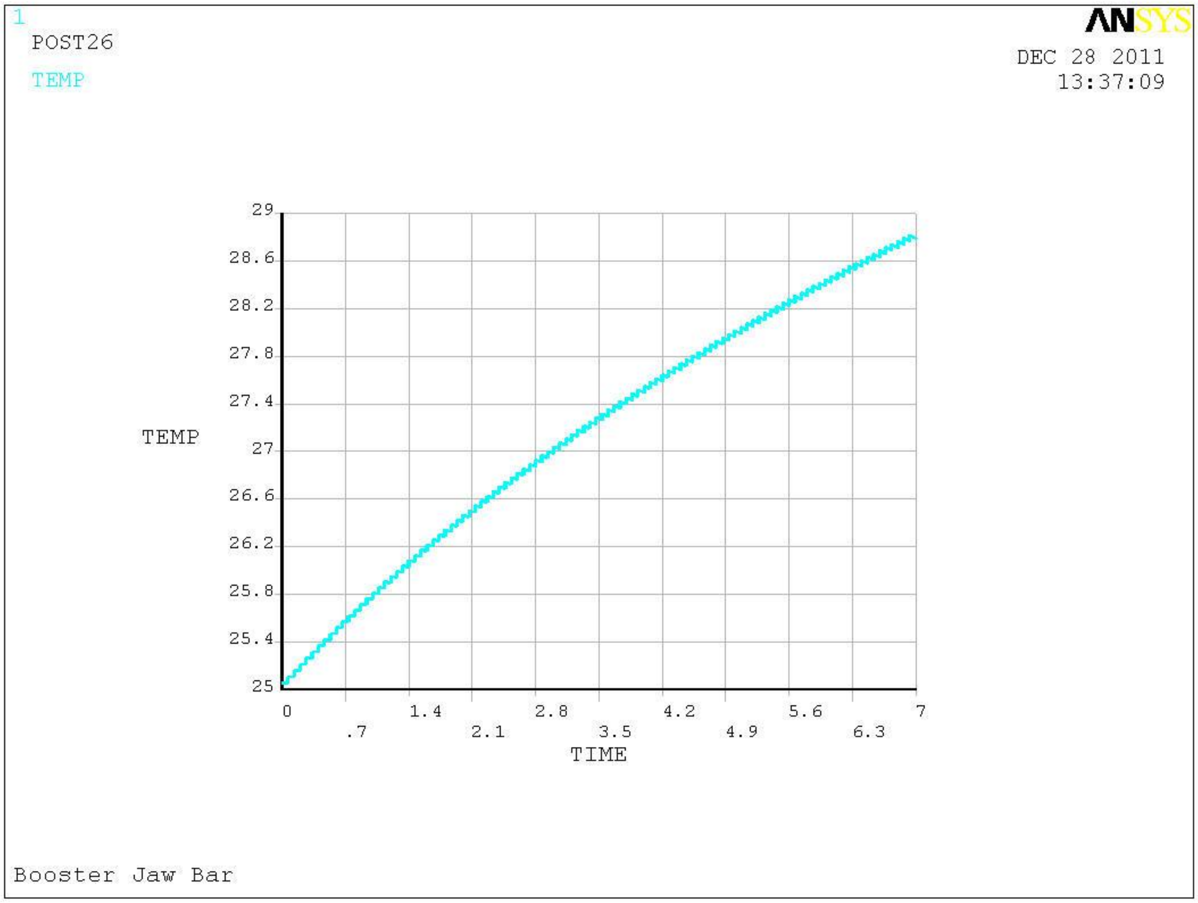
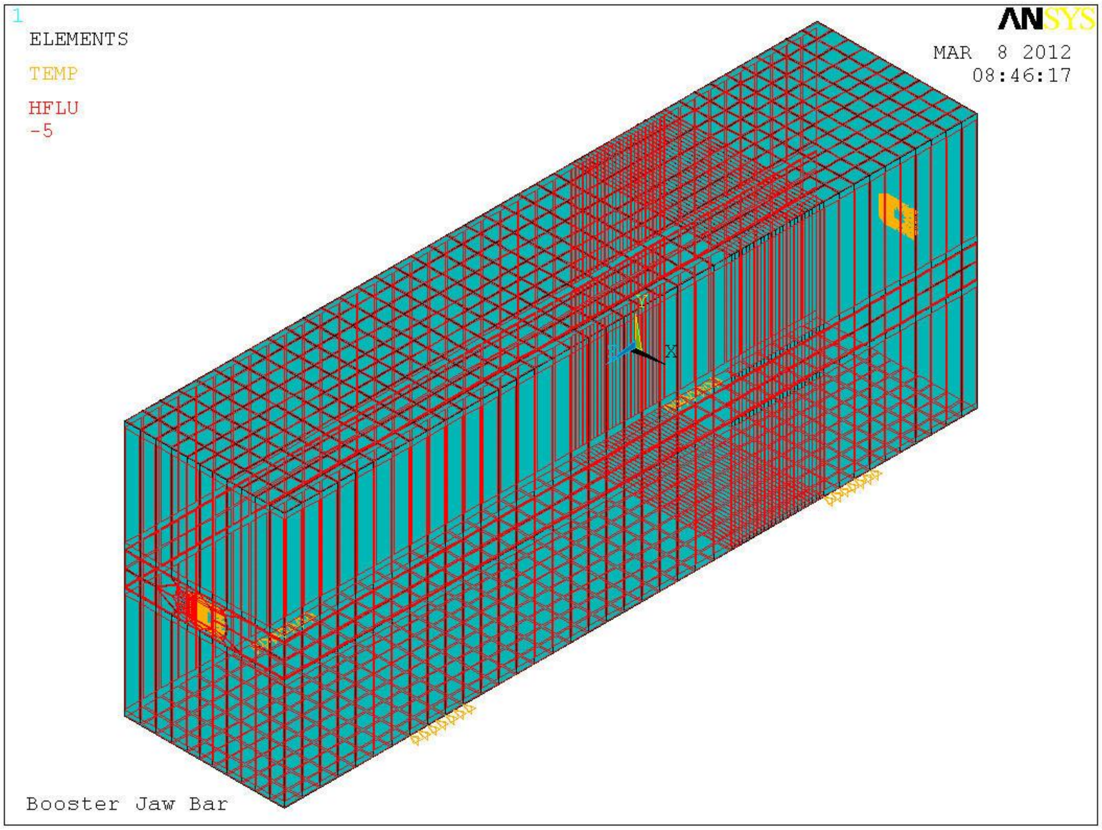


Fig.28 Instant temperature rise.



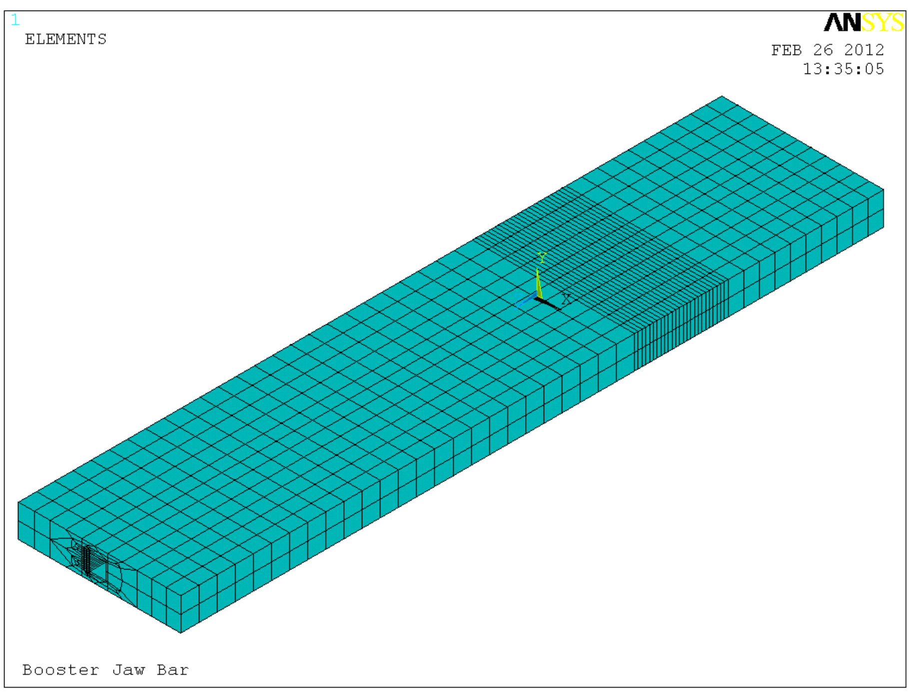
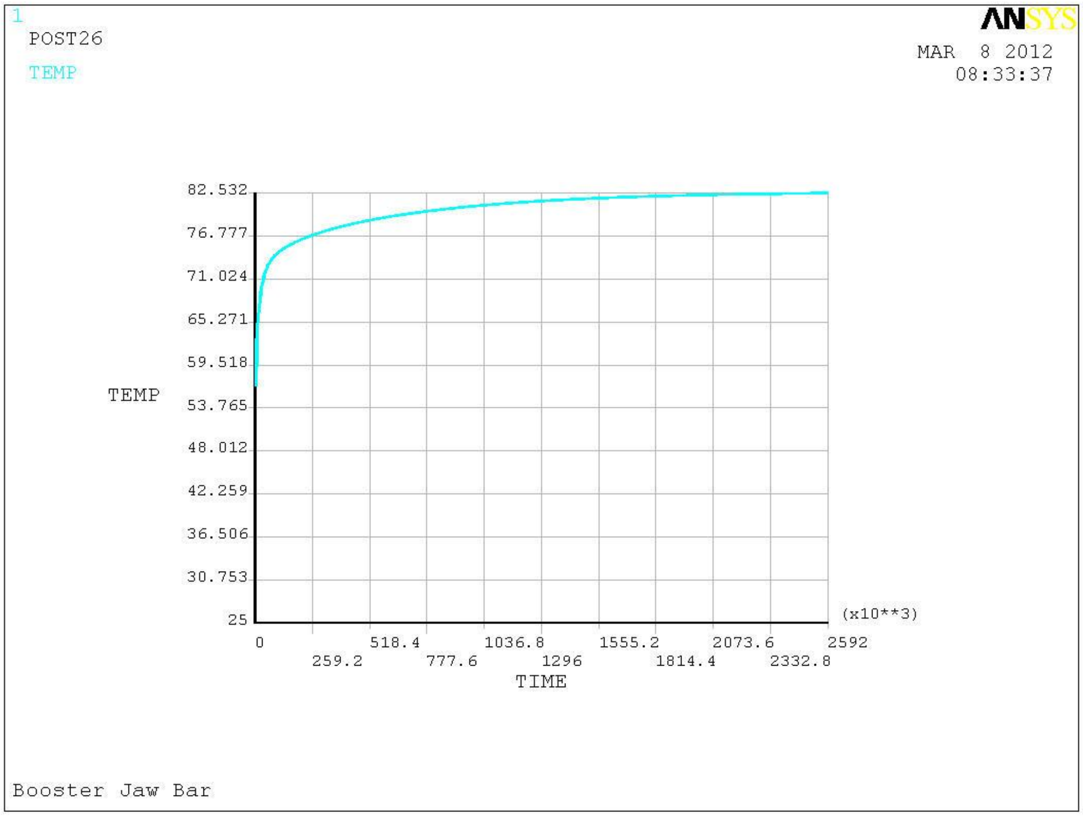


Fig.29 Calculations model.



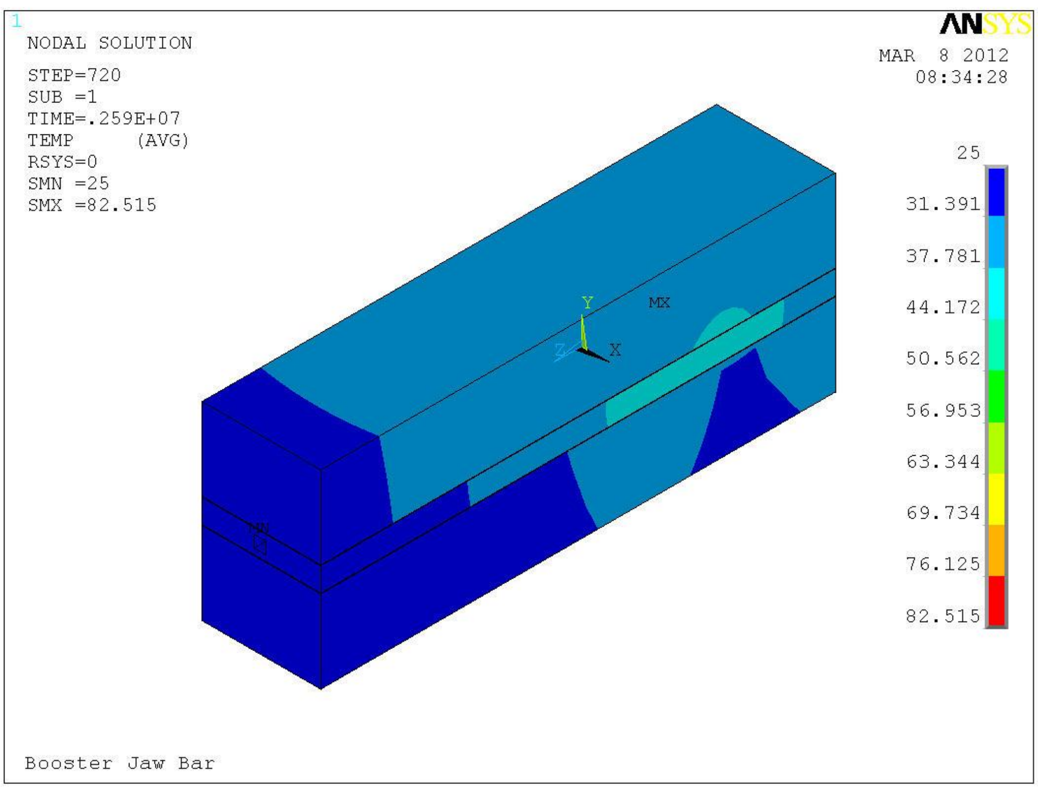
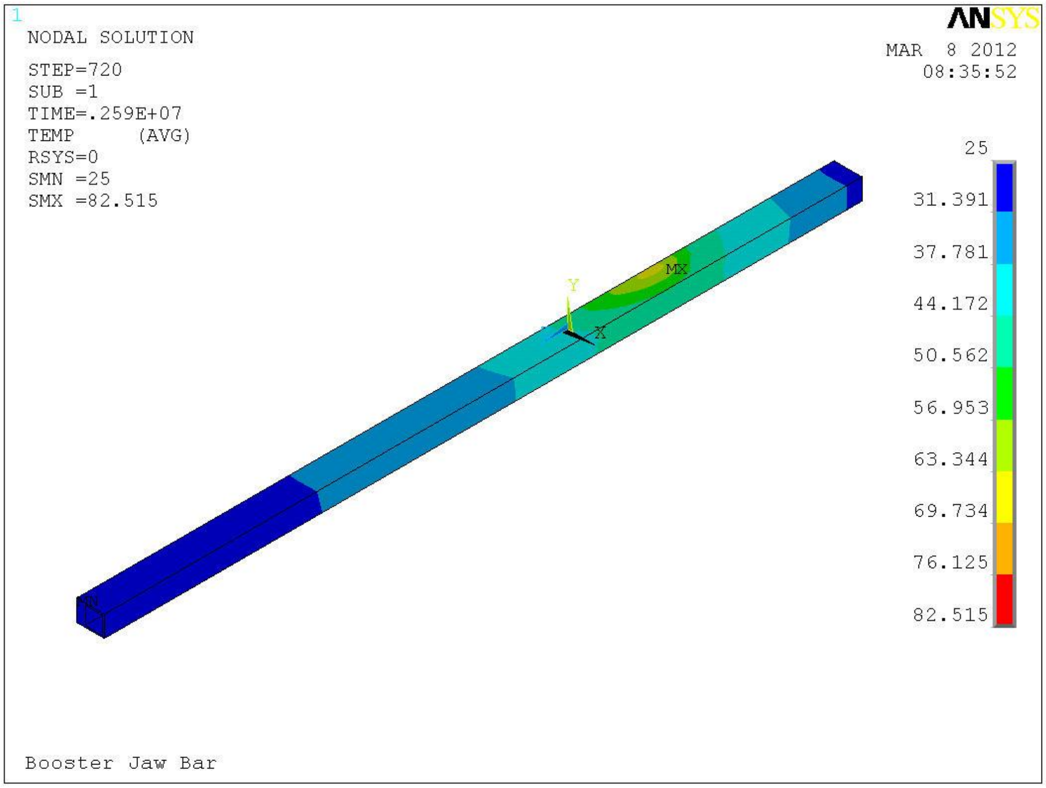


Fig.30 The notch absorber temperature.



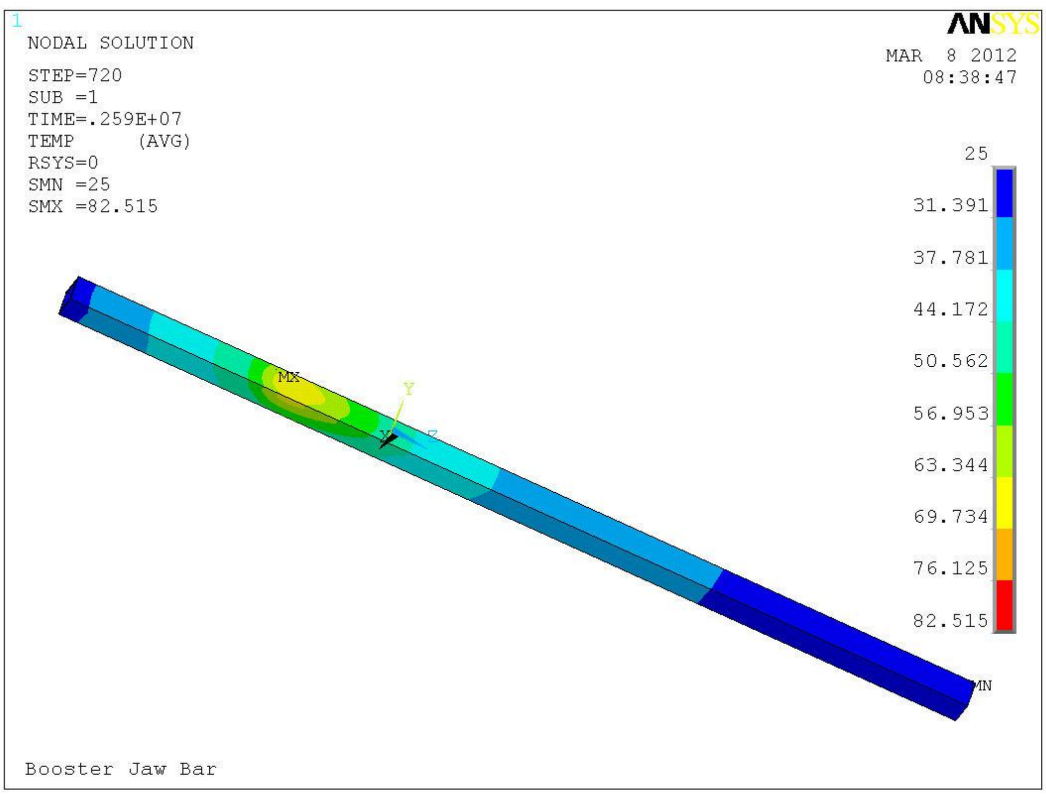
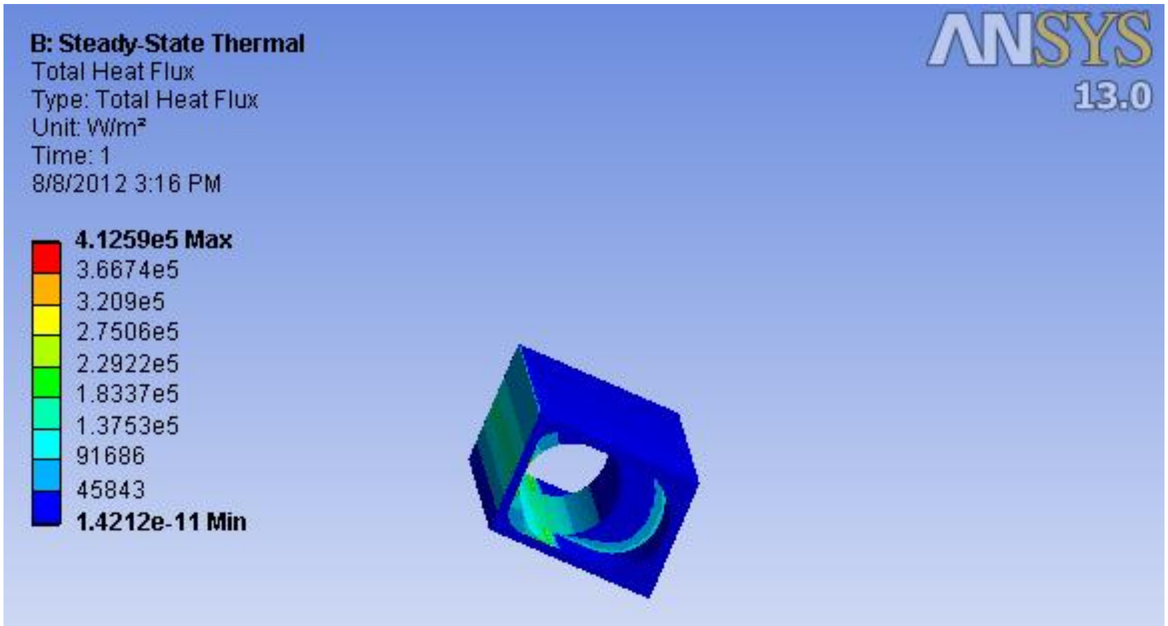


Fig.31 The vacuum liner temperature



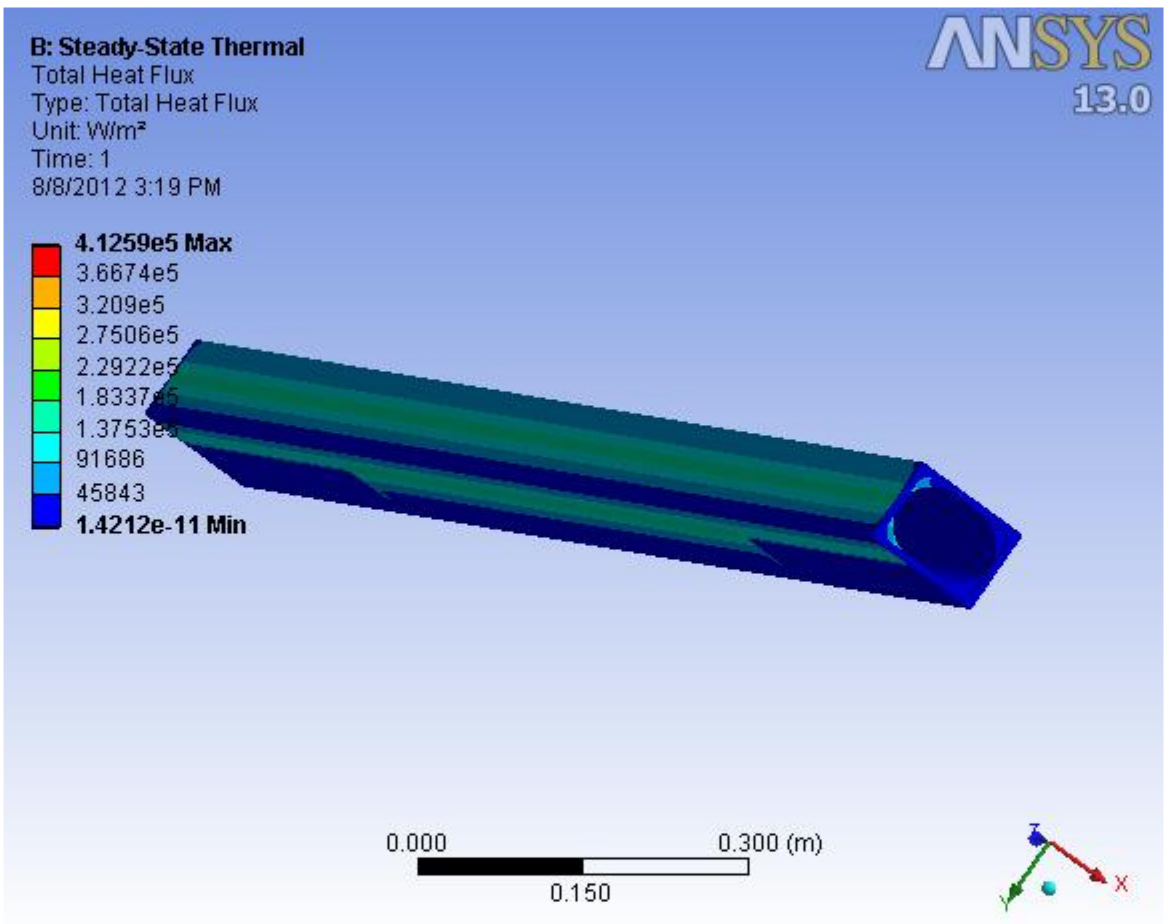


Fig. 32 Heat flux in the vacuum liner

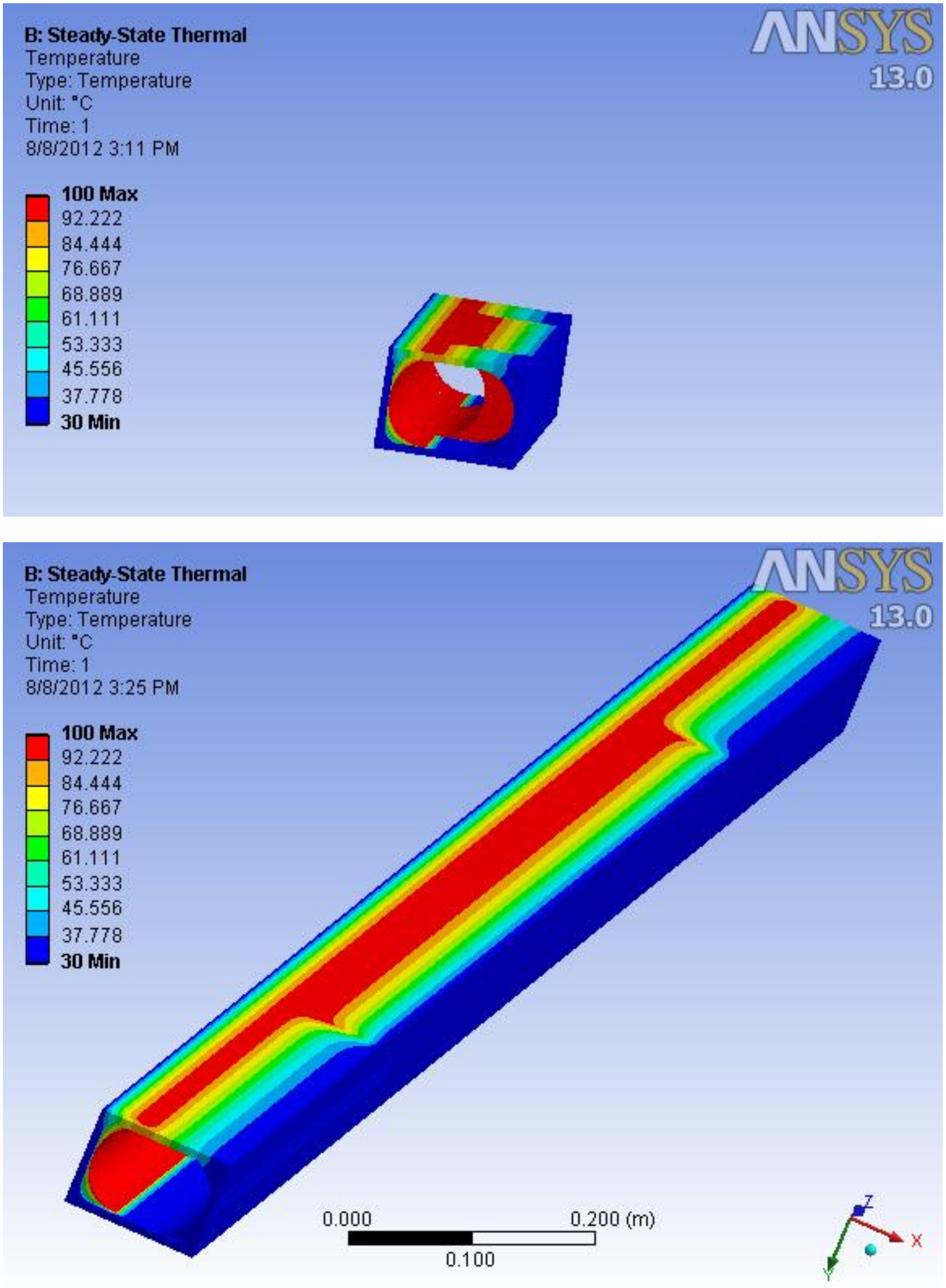


Fig.33 Vacuum liner temperature.